DESIGN AND CONSTRUCTION OF HIGHWAY BRIDGE

OVER ETOWAH RIVER NEAR CARTERSVILLE, GEORGIA.

A THESIS

Submitted for the Degree of

MASTER OF SCIENCE IN CIVIL ENGINEERING

Georgia School of Technology

By

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B. S. in C. E. 1924

THE UNIVERSITY OF GEORGIA

Approved by:

SPECIAL COMMITTEE ON APPROVAL.

Date: May 20 1932

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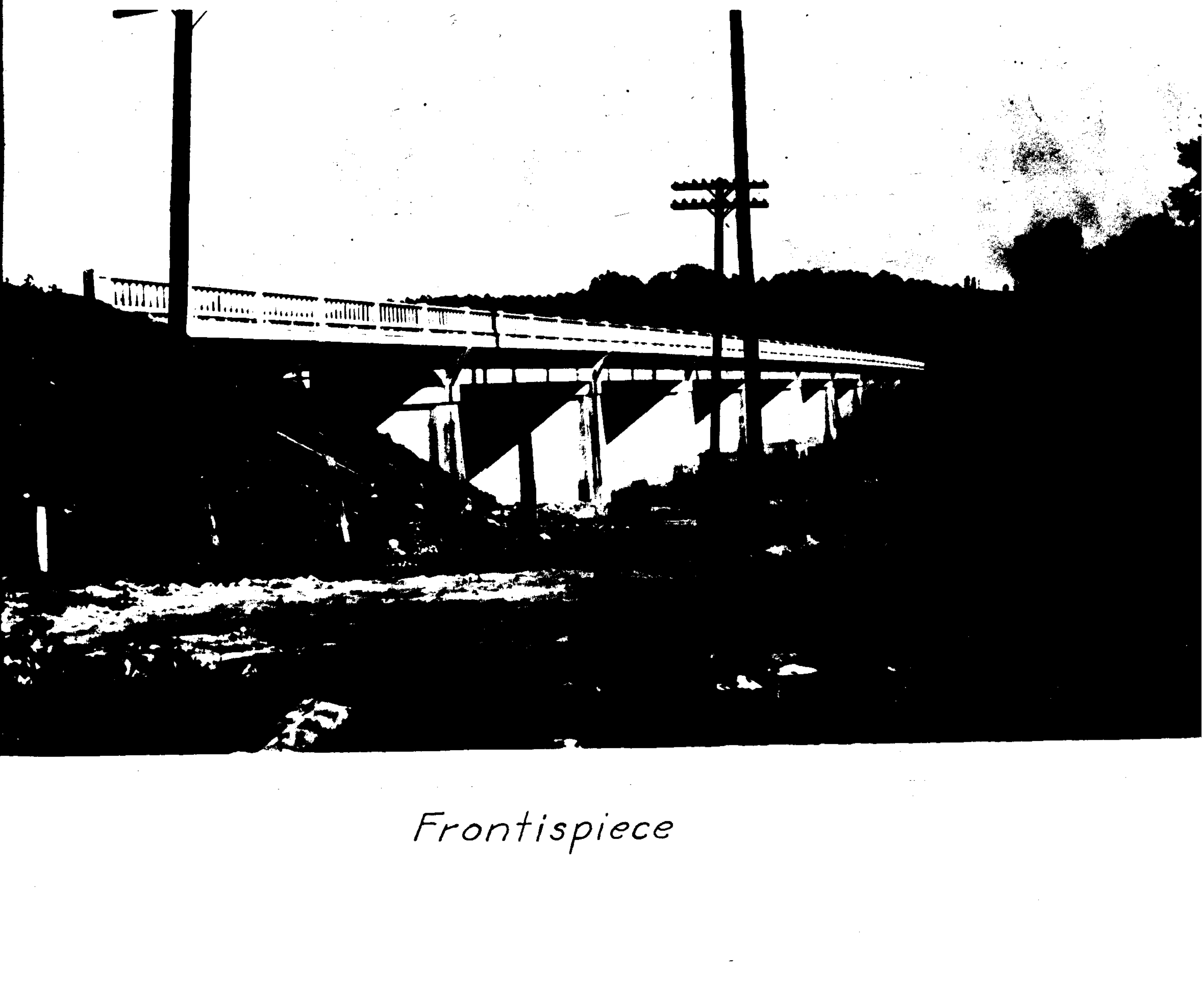


Frontispiece

PREFACE

The intention of the writer of this thesis was to present complete, actual computations made for the design of the Etowah River Bridge, mention being made of all conditions that had to be considered before the type of bridge, length of bridge, and height of bridge (or finished grade of bridge, as those familiar with bridge design term it), was decided upon, in such a manner and style as to be clearly understood and easily followed by those inexperienced in bridge design.

The writer has tried, also, to give as clear a description as his ability permits, of the actual construction of the bridge. Generally speaking, conditions are encountered during construction that necessitates certain changes being made in the design. This is especially true with regard to the design of the bridge foundations, unless elaborate sounding equipment is available to determine, for a certainty, the character of material upon which the pier and bent footings are to rest. The State Highway Department of Georgia has no such equipment, and the soundings for this bridge, as is the usual custom, were made with a rod. All variations from the original design which were found necessary in some cases, and deemed advisable in others, have been dealt with; as well as various other lesser problems that were encountered during construction.

Books used for reference in the design are: "Concrete Plain and Reinforced", Taylor and Thompson; "Concrete Engineers' Handbook", Hool and Johnson; and the Georgia State Highway Department's Standard Specifications for Bridges, a copy of which is included.

In choosing a subject for a thesis, the writer decided it would be interesting and instructive, to those not engaged in bridge building, as well as to those interested in bridge design and construction, if the design and construction of a modern reinforced concrete bridge were presented in a descriptive and explanatory manner. The decision to choose this particular subject was due, in a large measure, to the fact that many people visited the bridge site during construction to see just how concrete was made to take the shape of the finished bridge - and many were the questions asked.

The writer was also influenced in choosing this subject as a result of having been fortunate enough to participate in the design of the bridge; and then of being made resident engineer in charge of the bridge during construction. Thus, first hand information, only, is given.

The computations on design, and also the computations of the quantities of different items of materials that went into the construction of the bridge, have been checked, and therefore should be correct.

Bids are accepted by the State Highway Board on all Highway projects let to contract, and, inasmuch as the contractor's bid is on the basis of a unit price for the different items such as cubic yards of concrete, pounds of reinforcing steel, cubic yards of excavation, and etc., one may see that it is quite necessary for the computations on quantities to be checked as well as those on design.

Sincere appreciation is hereby expressed to Professors F. C. Snow and J. M. Smith, of the Georgia School of Technology, for their kind criticisms and suggestions in the preparation of this thesis; to the bridge department of the State Highway Board of Georgia for permitting the writer to use the computations and construction notes on this bridge; and to Mr. M. L. Fleetwood of Cartersville, Georgia, President and Editor of the Cartersville Tribune-News, who very graciously presented the writer with a copy of The Tribune-News of June 27, 1929, a special edition advertising Bartow County, from which certain facts given in the introduction to this thesis relative to Bartow County, were obtained.

INTRODUCTION

The bridge referred to in this thesis spans the Etowah River about one mile south of Cartersville, Georgia, on Route No. 3, one of the heaviest travelled highways through the State.

Cartersville is the county seat of Bartow County, and inasmuch as Bartow County is one of the most interesting counties in the State of Georgia from a historical and geological point of view, as well as in other respects, it perhaps will be well to mention some of the most interesting facts concerning this County.

In 1838, the Indians were ordered sent West of the Mississippi and all the lands of Cartersville and Cass County, now Bartow County, were turned over to the white men. The removal of the Indians allowed far greater freedom on the parts of the white settlers; allowed them to make greater attempts at progress in the mining, farming, and transportation industries.

As a result of these operations Bartow County is now declared by State and Federal geologists to have more different kinds of minerals in commercial quantities than any like area in the whole world.

Within a radius of twenty miles of Cartersville may be found almost unlimited deposits of ochre, barytes, manganese, brown iron ore, slate, and limestone, now being mined and shipped to all parts of the world.

Farming is also an interesting activity of Bartow County; cotton, feed stuffs, poultry, and peaches being the products of most note.

The Goodyear Tire and Rubber Plant and the Cartersville Mills, both located in Cartersville, are said to be two of the best manufacturing plants of their kind in the South; thus establishing Bartow County as a manufacturing center.

Cartersville bears the distinction of being the home of some very famous people, notably among them being Sam P. Jones, evangelist; Mrs. Rebecca Latimer Felton, the first and only woman ever to occupy a seat in the United States Senate; Corra Harris, who occupies a place as one of America's first women of letters; and Major Charles H. Smith, known to the world of letters as Bill Arp, writer of famous Southern stories.

Near Cartersville are some of the most historic sites in the South. The Etowah Mounds on the Tumlin Farm have been pronounced by archaeologists from Smithsonian Institution, Harvard, and other seats of learning as without an equal on the American continent. Explorations during the past few years, headed by Dr. Warren K. Moorehead from Andover Academy, of Massachusetts, have resulted in the finding of one hundred and fifty remains of a prehistoric race, the work being pronounced of far reaching importance in the study of ethnology. Scientific men from many states have visited the mounds, and have stood in awe at their size, and speculated widely upon why they were built by a people about whom very little is known.

During the construction of the Etowah River Bridge, Dr. Moorehead conducted one of his explorations. It was the writer's good fortune to be able to visit the mounds several times while this work was in progress, and to view quite a few of the skeletons and relics as they were uncovered.

About five miles up the Etowah River above the bridge site, stand several old rock walls; all that remained of the community surrounding Cooper's Iron Works after Sherman's devastating march through Georgia. This community was in existance long before the birth of Cartersville.

Another point of interest in Bartow County is Saltpetre Cave five miles west of Cartersville, which was operated in the manufacture of munitions during the Civil War. It is reached by a winding path up the side of a mountain, thence down the sloping entrance, and on into the darkness of the tunnel that leads into the cavern. It rivals the Mammoth Cave of Kentucky in size and mystery, yet remains in its primitive beauty and seclusion, very little of it having ever been explored.

The preceding paragraphs should give the reader a fair idea of the picturesque and famous locality in which the bridge was to be built. Thus, one sees that it was important to give some consideration to esthetics in the design of the bridge. Also, the people of Bartow County wanted this to be a memorial bridge in honor of the World War veterans from Bartow County, and were directing their efforts towards the building of suitable parkways and monuments at the ends of the bridge, before the bridge was designed. It later developed that they were unable to finance such an undertaking and had to content themselves by placing a bronze tablet in the end post of the bridge. A picture of this is shown as platel.

Plate 1

The bridge to be replaced by the new concrete bridge was an old covered wooden lattice type of structure; a type that was once very common in the South but seldom seen now, and was about three hundred feet downstream from the new bridge site.

This bridge had a roadway of about sixteen feet, which permitted two vehicles to pass provided they did not meet at panel points. Two braces on each side extended from the eaves of the bridge down through the floor at a point about three feet from the walls at panel points; thus making it impossible for one vehicle to pass another at a panel point.

This within itself was a grave danger to motorists not familiar with the construction of the bridge; especially for those passing through it at night.

Aside from this it was necessary to make an abrupt right angle turn at the south end of the bridge, which was extremely perilous to those travelling southward who were not familiar with the road.

Then, too, the capacity of the bridge was wholly inadequate for the heavy trucks and loadings of the present era on such a heavily travelled highway.

Hence, a modern bridge designed to carry typical loadings, and with all possible hazards to motorists eliminated, was necessary.

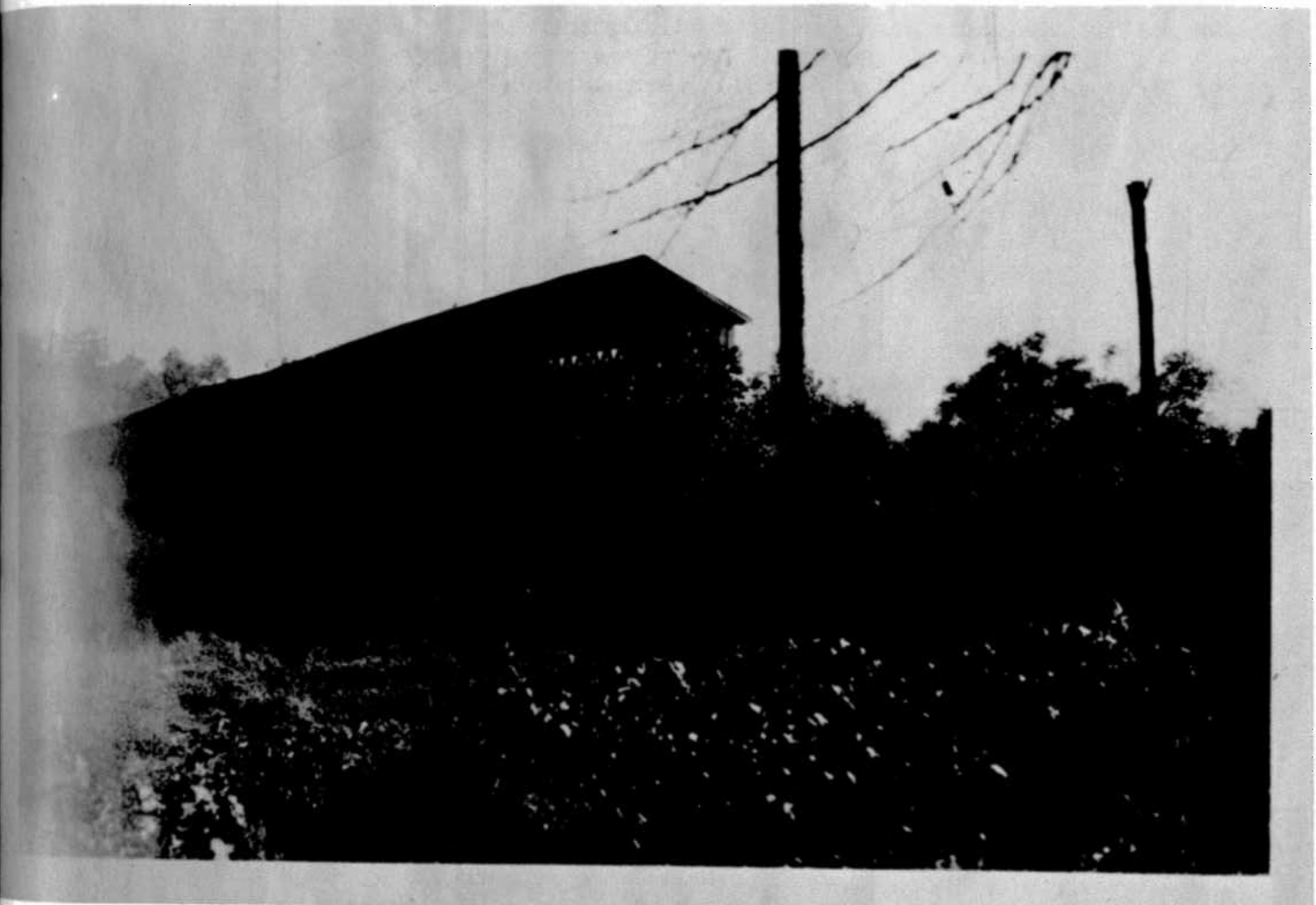


Plate 2

Old covered bridge that was replaced

STUDY OF TYPES

A steel bridge was never considered for this crossing for several reasons, viz; it was not necessary to span the river with a single span, which would have been the case had the river been navigable; or which would have been economical had the river bed been such a gorge as to require extremely high intermediate piers and difficult foundation work for river footings. Then, too, a steel truss would not have been as suitable from an aesthetic viewpoint as a concrete bridge; and an arch bridge either of steel or concrete was not practical due to lack of suitable foundation material.

Although a few arch bridges have been built with piles driven at an angle to take the horizontal thrust from the arch ring, it is generally considered necessary, and certainly advisable, to have a solid rock foundation. The more nearly the plane of the rock approaches a right angle to the horizontal thrust of the arch, the more satisfactory it is as an arch foundation.

A study of the profile on the Plan and Elevation sheet of the bridge will show that a suitable arch foundation does not exist. Hence, an arch type of bridge was not considered.

A concrete continuous-cantilever-suspended span type of bridge would have been a much prettier bridge than the girder type, which was finally decided upon, and would have afforded much longer clear spans, which are especially desirable over the main channel of a stream; but there were serious objections to this type.

With further reference to the Plan and Elevation sheet, it will be noted that, approximately, an eighteen foot fill was required at each end of the bridge for the girder type bridge, and even this allowed an extremely low margin of safety of only a little more than a foot of clearance between the bottom of girders and extreme high water. Whereas, due to the high negative bending moment which requires a proportionately large depth of girders over supports in the concrete continuous-cantilever-suspended type of design, the bridge would have had to be at least three feet higher than at present to obtain the same high water clearance. This would have necessitated an equally higher fill at the ends of the bridge, thereby increasing the hazard to motorists, as well as being very costly construction. The cost of fill material was quite a consideration in the type selection of bridge for this location because of the facts that both fills were several hundred feet long, and, also, that it was quite a distance from the source of the fill material to the final placing thereof, thus necessitating a long haul.

At the time this bridge was designed the steel mills were not rolling the large 30, 33 and 36" I-beam sections, as they are now, or the design would probably have been an I-beam continuous-cantilever-suspended span type, with a concrete floor slab. At present, this type of design is providing an economical as well as a sightly type of structure, and is much simpler to build requiring very little falsework.

In most cases, it is possible to so balance the lengths of the continuous span, cantilever arm, and suspended span that the same section modulus is sufficient for the moment at all points, thus eliminating the main objection where it is desired to keep the bridge as low as possible, of increased depth in girders, which becomes necessary for the concrete continuous-cantilever-suspended type. Even when the negative moment over supports does require some additional section in I-beam construction, this may be provided for by cover plates which add no appreciable depth to the superstructure.

Finally a concrete girder bridge was the type decided upon by Mr. S. B. Slack, Bridge Engineer for the Highway Department.

Then came the question as to what length of bridge was necessary, and what length or combination of lengths of decks comprising the bridge, would be economical as well as suitable for this particular location.

LENGTH, FINISHED GRADE, AND OTHER CONSIDERATIONS.

The length and finished grade of a bridge are both dependent upon the amount of opening required to permit as nearly as possible a normal discharge of the water under the bridge during flood stage. If the bridge is too short, the water is abnormally confined causing it to back up, thereby increasing its head, which in turn causes it to discharge more rapidly under the bridge, although not rapid enough to overcome the lack of required opening, and at times, due to the eddies created, resulting in serious scour around foundations.

Also, the water would continue to back up until it broke over the fill approaches, making the road impassable; and, in most cases, washing portions of the fill way. Hence, the determination of the length of a bridge requires very careful study.

First, it was necessary to know what area was drained by the Etowah River above the bridge site, and what constant in Talbot's formula for area of opening required should be used. The area drained was classed as hilly terrain and a constant of 0.6 was selected as being the most applicable.

From a Government soil survey map, the area drained by the Etowah River above the bridge site was sketched off, then planimetered. By making the proper computations to convert the square inches as read on the planimeter into square miles, the drainage area was found to be 1160 square miles. From Talbot's formula, using the above constant of $C = 0.6$, the area of opening required under high water was found to be approximately 14000 square feet.

Next, the elevation of extreme high water at the proposed bridge site had to be obtained. This was secured by a study of water marks on the trees along the river banks, and supplemented by statements of old time settlers living nearby. Incidentally, normal high water was also obtained in this manner, although extreme high water was the prime consideration. The elevation, with reference to the datum plane used for this survey, of extreme high water was found to be 702.2 as shown on the Plan and Elevation sheet.

With the above data in hand, it was estimated that a bridge approximately 1000 feet long would be required. However, a few hundred feet up stream, the N. C. & St. L. Railroad spanned the river with a bridge of about half that length, and their bridge, from all indications, provided ample opening. This condition, I might add is not unusual, inasmuch as it is often encountered. Talbot's formula is not an absolute guide to the area of opening required for a stream, but it is an approximate guide which has to be used in conjunction with other data, if other data is available.

After determining that the N. C. & St. L. bridge did provide sufficient opening, there would have been no advantage in building a bridge with a much greater opening just below it, so a highway bridge with the same approximate area of opening under high water was laid out and designed.

This required a bridge about 500 feet long, after deducting the area of piers and bents which would necessarily reduce the area of opening by their presence; and, also, after making a correction to reduce the area of opening from that as shown on the elevation of bridge to what it would be were the bridge built at right angles to the flow of the river. It will be noted that the river flows under the bridge at approximately a 60° angle. Hence, the actual effective opening would be that as shown multiplied by the sine of 60°.

Since the river did flow at an angle to the center line of the location of the bridge, it was readily seen that a skew bridge would be necessary; that is, the substructure consisting of bents and piers would have to be built approximately parallel to the flow of the river instead of perpendicular to the center line of the bridge, in order to obtain a minimum of resistance to the current.

Although it is usually the practice of the bridge department of the State Highway to allow a minimum of 1.5 feet clearance between extreme high water and the lowest point of the superstructure, as a measure of safety, it was not done in this case. However, the minimum clearance was more than a foot.

To the elevation of high water was added the clearance above high water plus the depth of girders, slab, and paving, thus obtaining the elevation of finished grade on the deck selected to be the control grade for the bridge. This happened to be the deck between piers 6 and 7, since it was approximately at the center of the bridge.

Next came the question as to what combination of lengths of decks would be economical for this bridge. It was desirable to use the longest decks available for spanning the river proper in order that there would be no more piers than absolutely necessary to offer resistance and catch drift during flood stages.

Although the State Highway Department specifications permit the use of concrete girder spans up to 60 feet, they become very uneconomical for spans greater than 40 or 50 feet, and for this reason the longest concrete girder-slab-T-beam type deck used by the Highway Department is 52 feet in length.

Therefore, the question of lengths of decks to use resolved itself into a question of what length of approach decks, in combination with the 52 foot decks would be most suitable and economical.

They only way to answer the question was to work up comparative estimates based on layouts using the different lengths of decks, in combination with the 52 foot decks, that would give approximately the same length bridge.

As stated previously, a bridge about 500 feet long was desired,so estimates on the following combinations of decks were worked up and are given below:

6 @ 52 ft. + 6 @ 34 ft. = 516 ft.; 4 @ 52 ft. + 9 @ 34 ft. = 514 ft.; 4 @ 52 ft. + 8 @ 38 ft. = 512 ft.; and 10 @ 52 ft. = 520 ft.

It will be noted in the tables below, two items of excavation appear, viz; excavation No. 1 and excavation No. 2. By excavation No. 1 is meant the amount of excavation, figured for an area one foot larger on all sides than the actual size of the footing, necessary to reach the elevations of the bottom of footings as shown on the plans.

In case suitable foundations are not encountered at the elevations shown on plans, the excavation has to continue until a satisfactory foundation is reached, and this excavation is called excavation No. 2. For estimating purposes, a depth of 2 feet is arbitrarily used in all cases to compute excavation No. 2; this being done in order that a unit price for excavation No. 2 will be included in the bid, thus eliminating any cause for argument in case it does become necessary during construction to carry any of the foundations lower than plan elevations.

COMPARISON OF LAYOUTS AND COSTS

6-52' DECKS ≠ 6-34' DECKS = 516 FT. BRIDGE

Member	Class "A" Concrete	Class "B" Concrete	Reinforcing Steel	4" Concrete Paving	Type "F" Hand Rail	Excav. No.1	Excav. No. 2	Piling
	Cu.Yds.	Cu.Yds.	Lbs.	Sq.Yds	Lin.Ft.	Cu.Yds	Cu.Yds.	Lin.Ft.
6-52' Decks Skewed 60°	463.92		76,392	624	624			
6-34' Decks Skewed 60°	214.80		40,506	408	408			
2-14' End Bents	64.50		3,000			84	31	540
7-19' Piers		261.66	15,988					
7-7'x6' Pier Bases		336.00				426	95	
4 Int. Bents	48.92		7,112					
4-6'x5' Bent Bases	106.56					202	25	
Totals	898.70	597.66	142,998	1032	1032	712	151	540
Call it	900	598	143,000	1032	1032	712	151	540

ESTIMATE OF COST

900	cu.yds.	Class "A" Concrete	@	$ 26.00	=	$ 23,400.00
598	cu.yds.	Class "B" Concrete	@	24.00	=	14,352.00
143000	lbs.	Reinf. Steel	@	.06	=	8,580.00
1032	sq.yds.	4" Concrete Paving	@	2.00	=	2,064.00
1032	lin.ft.	Type "F" Hand Rail	@	2.50	=	2,580.00
712	cu.yds.	Excavation No. 1	@	3.00	=	2,136.00
151	cu.yds.	Excavation No. 2	@	6.00	=	906.00
540	lin.ft.	Foundation Piling	@	1.25	=	675.00
					Total	$ 54,693.00

4-52' DECKS ≠ 9-34' DECKS = 514 FT. BRIDGE

Member	Class "A" Concrete	Class "B" Concrete	Reinforcing Steel	4" Concrete Paving	Type "F" Hand Rail	Excav. No. 1	Excav. No. 2	Piling
	Cu.Yds	Cu.Yds	Lbs.	Sq.Yds	Lin.Ft.	Cu.Yds.	Cu.Yds.	Lin.Ft.
4-52' Decks Skewed 60°	308.28		50,928	416	416			
9-34' Decks Skewed 60°	322.20		60,759	612	612			
2-14' End Bents	64.50		3,400			84	31	92@
7-18' Int. Bents	105.00		9,100			105	42	15'
5-19' Piers		186.90	11,420					
Pier Bases		364.90				272	53	
Totals	799.98	551.80	135,607	1028	1028	461	126	1380
Call it	800	552	135,700	1028	1028	461	126	1380

ESTIMATE OF COST

800	cu.yds.	Class "A" Concrete	@	$ 26.00 =	$20,800.00
552	cu.yds.	Class "B" Concrete	@	24.00 =	13,248.00
135700	lbs.	Reinforcing Steel	@	.06 =	8,142.00
1028	sq.yds.	4" Concrete Paving	@	2.00 =	2,056.00
1028	lin.ft.	Type "F" Hand Rail	@	2.50 =	2,570.00
461	cu.yds.	Excavation No. 1	@	3.00 =	1,383.00
126	cu.yds.	Excavation No. 2	@	6.00	756.00
1380	lin.ft.	Foundation Piling	@	1.25	1,725.00
				Total	$ 50,680.00

4-52' DECKS + 8-38' DECKS = 512 FT. BRIDGE

Member	Class "A" Concrete	Class "B" Concrete	Reinforcing Steel	4" Concrete Paving	Type "F" Hand Rail	Excav. No. 1	Excav. No. 2	Piling
	Cu.Yds.	Cu.Yds.	Lbs.	Sq.Yds.	Lin.Ft	Cu.Yds	Cu.Yds.	Lin.Ft.
4-52' Decks Skewed 60°	308.28		50,928	416	416			
8-38' Decks Skewed 60°	360.64		67,528	608	608			
2-14' End Bents	64.50		3,000			84	31	84 @
6-18' Int. Bents	90.00		7,800			90	36	15'
5-19' Piers		186.90	11,240					
Pier Bases		364.90				272	53	
Totals	823.42	551.80	140,496	1024	1024	446	120	1260
Call it	824	552	140,500	1024	1024	446	120	1260

ESTIMATE OF COST

824	cu. yds.	Class "A" Concrete	@	$ 26.00	=	$23,398.00
552	cu. yds.	Class "B" Concrete	@	24.00	=	13,248.00
140500	lbs.	Reinforcing Steel	@	.06	=	8,430.00
1024	sq.yds.	4" Concrete Paving	@	2.00	=	2,048.00
1024	lin.ft.	Type "F" Hand Rail	@	2.50	=	2,560.00
446	cu.yds.	Excavation No. 1	@	3.00	=	1,338.00
120	cu.yds.	Excavation No. 2	@	6.00	=	720.00
1260	lin.ft.	Foundation Piling	@	1.25	=	1,575.00
				Total		$ 53,317.00

10-52 DECKS = 520 FT. BRIDGE

Member	Class "A" Concrete	Class "B" Concrete	Reinforcing Steel	4" Concrete Paving	Type "F" Hand Rail	Excav. No. 1	Excav. No. 2	Piling
	Cu.Yds.	Cu.Yds.	lbs.	Sq.Yds.	Lin.Ft.	Cu.Yds.	Cu.Yds.	Lin.Ft.
10-52' Decks Skewed 60°	773.20		127,320	1040	1040			
2-14' End Bents	64.50		3,000			84	31	36 at 15'
9-19' Piers		334.55	20,556					
Pier Bases		420.00				560	96	
Totals	837.70	754.55	150,876	1040	1040	644	127	540
Call it	838	755	151,000	1040	1040	644	127	540

ESTIMATE OF COST

838	cu.yds.	Class "A" Concrete	at	$ 26.00	= $21,688.00
755	cu.yds.	Class "B" Concrete	at	24.00	= 18,120.00
151000	lbs.	Reinforcing Steel	at	.06	= 9,060.00
1040	sq.yds.	4" Concrete Paving	at	2.00	= 2,080.00
1040	lin.ft.	Type "F" Hand Rail	at	2.50	= 2,600.00
644	cu.yds.	Excavation No. 1	at	3.00	= 1,932.00
127	cu.yds.	Excavation No. 2	at	6.00	= 762.00
540	lin.ft.	Foundation Piling ?	at	1.25	= 675.00
			Total		$56,917.00

To summarize, we have -

6-52' Decks + 6-34' decks	= 516 ft. of bridge at a cost of	$54,693.00
4-52' decks + 9-34' decks	= 514 ft. of bridge at a cost of	50,680.00
4-52' decks + 8-38' decks	= 512 ft. of bridge at a cost of	53,317.00
10-52' decks	= 520 ft. of bridge at a cost of	56,917.00

The final decision on the combination of decks to use was made by Mr. S. B. Slack, Bridge Engineer for the Highway Department, and was in favor of the 6-52 ft. plus 6-34 ft. decks for the following reasons: First, there was not an excessively large difference in the amounts of the estimates of costs for the least expensive combination and that of the combination chosen; second, the combination chosen gave two more feet of bridge, and also had the advantage of 6-52' decks against 4-52' decks in the other combination. This was a decided advantage, for, as previously stated, it was desirable to span the river with as many of the longer decks as economically practical. The 10-52' decks were not considered for the reasons that the extra number of long decks were not thought to be worth the additional cost, and then they didn't fit the profile of the crossing quite as well as the combination chosen.

A solid concrete abutment was, at one time, considered for the Cartersville end of the bridge in lieu of the three column end bent which was built, but the idea was abandoned when a preliminary comparative estimate of cost showed a difference of $2100.00 in favor of the end bent. A solid abutment was rather desirable for this end of the bridge due to its proximity to the river and the potential danger of scour, but in view of the difference in cost, it was thought the three column open end bent,which permitted the roadway fill to slope through, would suffice provided the slope was thoroughly rip-rapped with good rock.

The bridge was designed, detailed, and traced, using the number and combination of decks as decided upon. However, before the contract was let, Mr. E. M. Arnold, Division Engineer, in whose division the bridge was located, made several recommendations by letter to the Highway Board with reference to changes he would like made in the bridge as laid out. The recommendation contained in the last paragraph of the letter with reference to adding an additional deck on the East end, was accepted and the plans were revised accordingly. At the same time, the decks, beginning with deck 9-10, were "squared" up.

The "wash" across the fields, referred to in the letter, was at approximately right angles to the center line of the bridge. Therefore, bents parallel to the "wash" were desirable, so a right angle layout was more suitable than a skew layout. Also, when possible, skewed designs are avoided since they are somewhat more difficult to construct, and, too, the decks have a tendency to crawl sidewise out of line due to expansion and contraction when skewed. A notable example of this may be seen just below Newnan, Georgia. Here, two concrete skew decks over the A. & W. P. Railroad have crawled about three inches out of line.

A photostatic copy of Mr. Arnold's letter is included as plate No. 8a just following this sheet. A photostat of the original layout of the bridge also follows as sheet No. 18a.

FORM H. D. 66 25M 9-26

STATE HIGHWAY BOARD OF GEORGIA

INTERDEPARTMENT CORRESPONDENCE

FILE

OFFICE Rome, Ga., Nov. 10, 1926

FROM E. M. Arnold, Division Engineer

TO S. B. Slack, Bridge Engineer, East Point, Ga.

RECEIVED NOV 12 1926 Highway Board of Ga. GENERAL OFFICE EAST POINT

SUBJECT Project G-1-1, Bartow County

ATTENTION MR. CROCKER

Beg to refer further considering location of bridge across Etowah River and am submitting a sketch made by Mr. Montgomery showing location of end bents and practical location of toe of fills. Please note that on the west end the fill will run within a few feet of the low water channel of the river and on the east end the fill will run into the small creek coming down from Emerson. There will need be about 1600 Sq. Yds. of rip rap work done to protect the end and sides of these fills and rip-rap material will probably have to be shipped in to this project as good rock is not available near this bridge. Also please note that borrow excavation will be hard to get.

Without balancing the cost of a proposed change in plans, I would like you to consider moving the west end of bridge 10 feet to the west and then adding one more span to bridge making the centers of end bents or abutments 111x61 and 116x81. Also please consider lowering the bridge if possible and also using counter-forted abutments. Abutments are especially desirable on east end on account of getting a roadway accessable to the pumping plant at the river used by two of the big mining companies of the district. If we cannot get this roadway underneath the end of bridge we are going to have to make an approach from the high fill which will cost several hundred dollars and still requires more borrow excavation.

Mr. Hamilton, the pump engineer at the river pumping plant, says that when there is an extreme high water that the current breaks through from the railroad bridge above, and crosses the survey about 116x00, and he thinks an extra span on east end would be required to keep the pumping plant from washing away. This seems reasonable, as there is a wash through fields above to this point.

Trusting that this data will not inconvenience you to any extent in getting out the finished plans for this bridge.

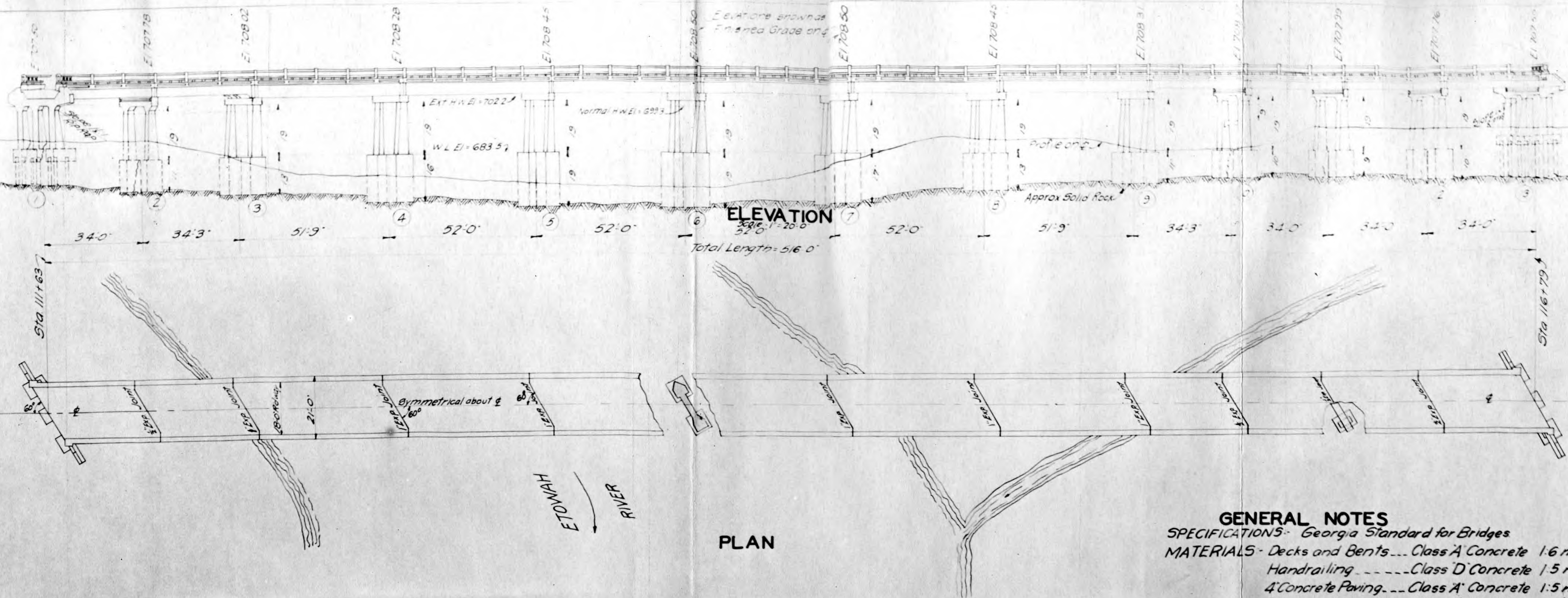
Yours very truly,

E. M. Arnold

E. M. Arnold
Division Engineer

WFM/H Enc.
Copy to
Hon. John N. Holder, Atlanta, Ga.

Plate 2a



Elevs. top of bents and piers caps on ¢ roadway and at end of caps. The upstream and downstream elevs. for bents No. 1 and No. 13 are at points from ¢ of roadway measured along caps.

Bent No.	Upstream	on ¢	Downstream
1	704.02	704.04	704.05
2	704.312	704.32	704.33
3	702.876	702.885	702.91
4	703.140	703.156	703.17
5	703.316	703.325	703.334
6	703.375	703.375	703.37
7	703.375	703.375	703.37
8	703.334	703.325	703.316
9	703.191	703.165	703.175
10	704.715	704.711	704.70
11	704.634	704.531	704.528
12	704.306	704.301	704.296
13	704.044	704.041	704.03

SUMMARY OF QUANTITIES

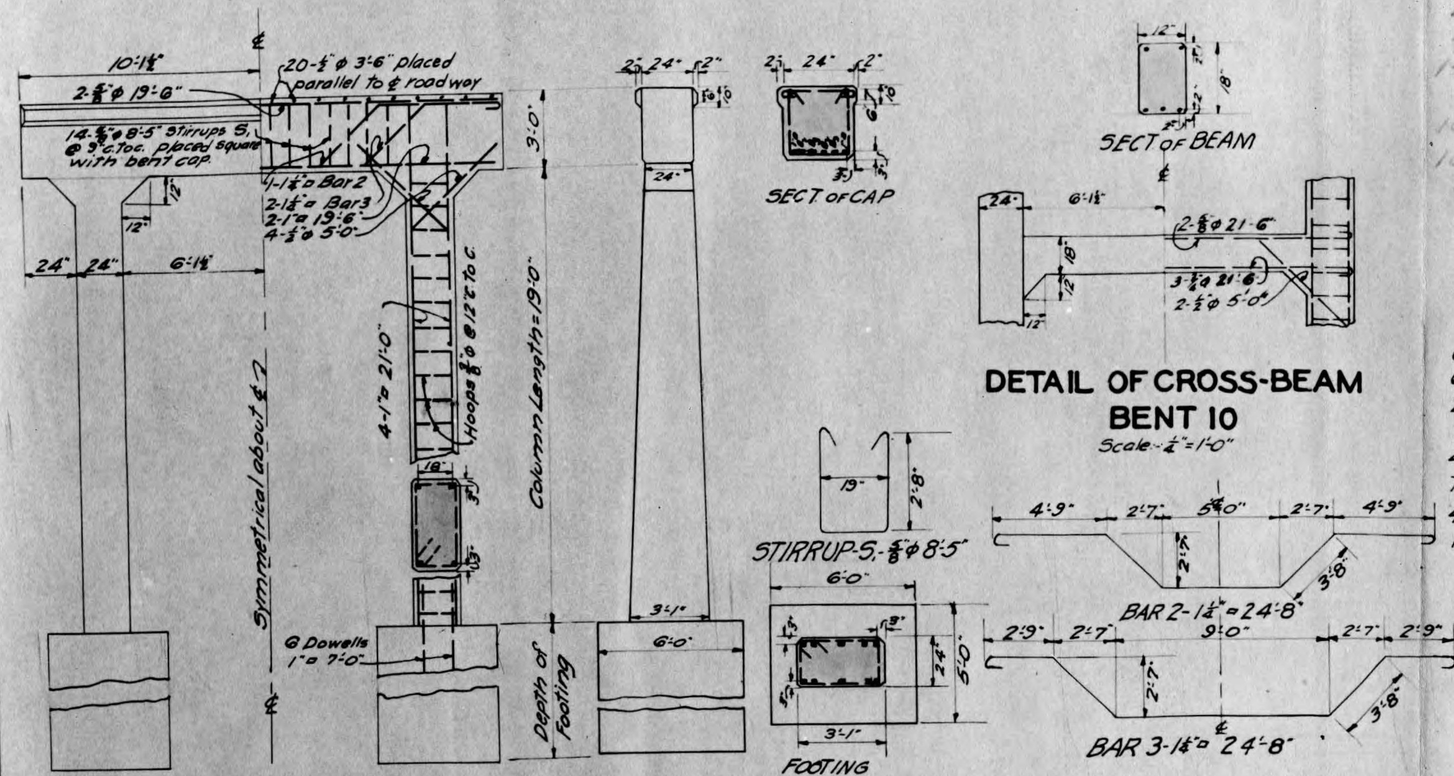
792 CU.YDS. CLASS "A" CONCRETE
262 CU.YDS. CLASS "B" CONCRETE - PIER SHAFTS
425 CU.YDS. CLASS "B" CONCRETE - PIER & INTER BENTS BASES
1434 LBS. REINFORCING STEEL
540 LIN.FT. FOUNDATION PILES
1032 LIN.FT. TYPE "F" HANDRAILING
1032 SQ.YDS. 4" CONCRETE PAVING
911 CU.YDS. EXCAVATION NO. 1
169 CU.YDS. EXCAVATION NO. 2 (IF REQ'D)

BRIDGE CONSISTS OF:-

6-52'0" DECKS - SKEWED 60° ----- GA. STD. No. 40 & 68-5
6-34'0" DECKS - " " 68 & 68-9
2-END BENTS - " " ----- SEE SPECIAL DESIGN
7-INTER PIERS - " " -----
4-INTER BENTS - " " ----- THIS SHEET
TYPE "F" HANDRAILING ------- GA. STD. No. 54
4" CONCRETE PAVING
FOUNDATION PILING - ESTIMATED 15' LONG

GENERAL NOTES

SPECIFICATIONS:- Georgia Standard for Bridges
MATERIALS - Decks and Bents --- Class "A" Concrete 1:6 mix
Handrailing ------- Class "D" Concrete 1:5 mix
4" Concrete Paving --- Class "A" Concrete 1:5 mix
Pier shafts ------- Class "B" Concrete 1:7½ mix
Pier & inter. bent bases, if poured dry - Class "B" Concrete 1:7½ mix
Pier & inter. bent bases if poured wet - Class "A" Concrete 1:6 mix
Reinforcing of steel bars.
CONSTRUCTION - All concrete for one deck must be poured continuously. No construction joint permitted between girders, slab and curbs.
Expansion joints of asphalt and felt formed thus (Expansion Material)
Chamfer all exposed edges ¾" unless noted
Excavation No. 1:- To bottom of footings as shown.
Excavation No. 2:- Below bottom of footings as shown (if req'd)
Bottom of footings shown approximate only. Carry all foundations to depths satisfactory to engineer.
Untreated foundation piles estimated 15' long
Forms for railing and curbs to be of dressed lumber at least 2" thick.
FINISH:- Top inside and outside of curbs, brackets and railing to have rubbed finish. Other parts spade finish. Remove excessive form marks. True up surface of slab with template and float.
RIP-RAP:- Riprap slopes thoroughly. Grouted riprap drains provided at both ends of bridge. Riprap and grouted drains to be placed by roadway contractor.
Omit drain holes in decks directly over riprapped slopes.
Old bridge approximately 800 feet downstream from proposed bridge.



DETAILS OF INTERMEDIATE BENTS 2-10-11 & 12
Scale:- ½" = 1'-0"

DETAIL OF CROSS-BEAM BENT 10
Scale:- ½" = 1'-0"

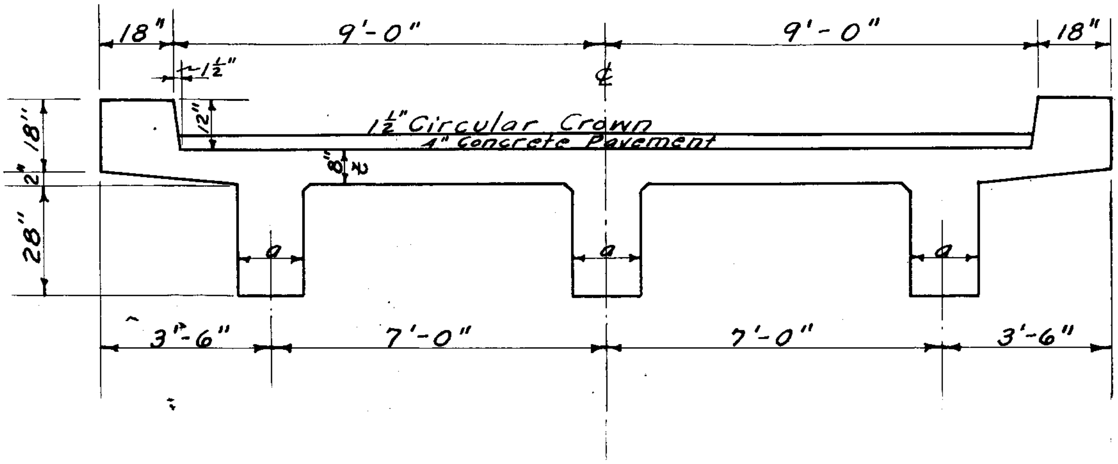
DRAINAGE DATA

DRAINAGE AREA = 1160 SQ. MILES.
AREA OF OPENING UNDER H.W. = 8930□'

STATE HIGHWAY DEPT. OF GEORGIA
DESIGN OF
BRIDGE OVER ETOWAH RIVER
BARTOW CO. PROJ. G-1-1
STA. 111+63 TO STA. 118+79
SCALES AS SHOWN — NOV.- 1926.
BRIDGE DEPT.

DESIGN OF THIRTY-FOUR FOOT DECK

SLAB



Assume slab thickness, t = 8"

Clear span, S = 5'-7" = 67"

(Of course this clear span length was assumed at first, then when the girders were designed, the moment was corrected for the exact clear span).

U.D.L. Slab = .67' x 5.58' x 1'x 150 = 560 lbs.

U.D.L. Paving = .33' x 5.58 x 1 x 150 = <u>280 lbs.</u>

Total = 840 lbs.

U.D.L. Moment = $\frac{wl}{10} = \frac{840 \times 67}{10}$ = 5,630 in. lbs.

L. L. Rear Wheel, H15 Loading (See Specifications) = .4x30,000 = 12,000 lbs.

Impact, $I = \frac{50}{L + 125} = \frac{50}{5.58 + 125}$ = 38% (See Specifications, Division III)

L.L. Rear Wheel + Impact = 12,000 + (12,000 x .38) = 16,600

Effective width = .7(2x2.79+1.25)=4.78 ft.(See Specs.,Page 15,Division III)

Therefore, the L.L. per ft. of width of slab = $\frac{16,600}{4.78}$ = 3.470 lbs.

With wheel at center of span,L.L.Mom =.205x3,470x67 =47,700 in. lbs.

Total Mom. = 5,630 ≁ 47,700 = 53,330 in. lbs.

Min. d = $\sqrt{\dfrac{53,330}{107.5 \times 12}} = \sqrt{41.4} = 6.43"$ Make t = 8"

(Specifications require $1\frac{1}{2}$" cover on slab reinforcing)

As Required = $\dfrac{M}{j\ d\ f_s} = \dfrac{53,330}{.875 \times 6.5 \times 16,000}$ = .586 sq.ins. per ft. of width of slab.

Use 5/8" Ø at 7" C. to C.

Max. Shear = D.L. ≁ L. L. = ($\frac{1}{2}$ x 840) ≁ (3220) = 3640 lbs.

Max. Unit Shear = $\dfrac{3640}{.875 \times 6.5 \times 12}$ = 53.5 lbs. per sq. in.

Under the specifications, 60 lbs. of shear per sq. in. may be allowed if reinforcing bars are bent up to carry part of the shear. Hence alternate slab bars are bent up over the girders. (See details of 34' deck).

OUTSIDE GIRDER

Net span = 33' = 396" (Span, as per specifications, to be c. to c. of supports)

D.L. Paving = 4.75 x .33 x 33 x 150	= 7,759 lbs.
D.L. Slab = 7 x .67 x 33 x 150	=23,216 "
D.L. Curb = 1x 1.5 x 33 x 150	= 7,425 "
D.L. Girder = 1.42 x 2.33 x 33 x 150	=16,378 "
D.L. Rail = 200 (lbs.per lin.ft.) x 33.	= 6,600 "
Total	61,378 lbs.(=1,860 lbs.per ft.)

$$\text{D.L. Mom.} = \frac{61,378 \times 396}{8} = 3,030,000 \text{ in. lbs.}$$

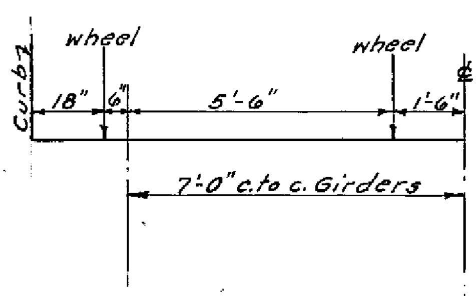
Live Load -

$$\text{Impact} = \frac{50}{L + 125} = \frac{50}{33 + 125} = 31.6\,\%$$

Rear Wheel L.L. = (.4 x 30,000) x 1.316 = 15,792 lbs.

Front " L.L. = (.1 x 30,000) x 1.316 = 3,948 lbs.

With one rear wheel 1'-6" from the curb (See specifications, Division III, page 7, for dimensions and clearance required for typical truck), the position of wheels with respect to the outside girder would be -

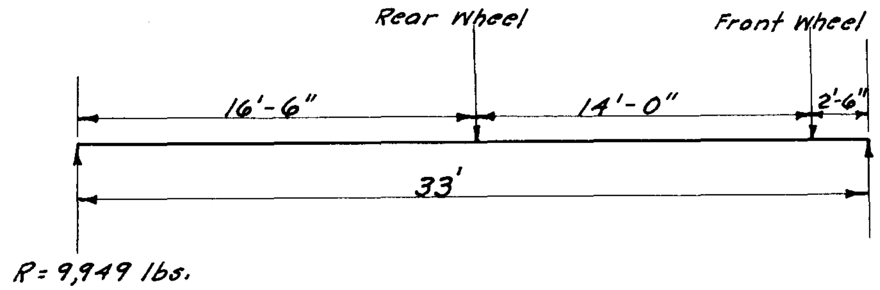


Therefore, the L.L. on the outside girder is -

Rear Wheels $= (15,792) + (\frac{1.5}{7} \times 15,792) = 19,172$ lbs.

Front " $= (3,948) + (\frac{1.5}{7} \times 3,948) = 4,796$ lbs.

L.L. Reaction with rear wheels at center of span is -



L.L. React. $= (\frac{1}{2} \times 19,172) + (\frac{2.5}{33} \times 4,796) = 9,586 + 363 = 9,949$ lbs.

L.L. Mom. $= 9,949 \times 16.5 \times 12 = 1,965,000$ in. lbs.

Total Mom. $= 3,030,000 + 1,965,000 = 4,995,000$ in. lbs.

Minimum d required for moment -

Assume min. d = 24" and b (width of T) = 81"; then $\frac{t}{d} = \frac{8}{24} = .333$

$C_d = 44 \quad j = .878$

(See pages 586 and 587 of "Concrete, Plain and Reinforced, by Taylor and Thompson, and Division III, page 41, of specifications governing b, width of T).

$$\text{Min. } d = \frac{M\,C_d}{j\,f_s\,b\,t} = \frac{4,995,000 \times 44}{.878 \times 16,000 \times 81 \times 8} = 23.6 \text{ ins.}$$

This checks closely enough for moment but before proceeding further it is necessary to compute the "d" required for shear.

Max. Reaction at support for shear = 1/2 total D.L. + L.L. =

$(\frac{1}{2} \times 61,378) + (19,172) + (\frac{19}{33} \times 4,796) = 50,137$ lbs.

Assume "d" for shear = 32" (Several were tried before the correct value was determined).

Then $\frac{t}{d} = \frac{8}{32} = .25 \quad C_d = 37 \qquad j = .899$

Unit Shear, $V = \dfrac{50,137}{.899 \times 32 \times 17} = \dfrac{50,137}{489} = 103$ lbs./sq. in.

The maximum allowable unit shear as per the specifications is 120 lbs./sq. in.

A "d" of 32" was used, thus giving a small margin of safety between the actual shear and the maximum allowable shear.

For d = 32", the area of reinforcing steel,

$$A_s, \text{ required} = \frac{M}{j \times d \times f_s} = \frac{4,995,000}{.899 \times 32 \times 16000} = 10.8 \text{ sq. in.}$$

Use 7- 1-1/8" sq. + 1-1/4" sq. bars.

Bars B, C, and D (see details of 34' deck) were trussed, which, as per specifications, must be done for unit shear above 60 lbs. per sq. in.

Bar B, 1-1/8" sq., is bent up 8'-3" from the center line. Hence, moment must be checked at this point to determine if the remaining bars provide sufficient reinforcing.

Mom. 8'-3" from center line (=8'-9" from end of girder)-

$$D.L.M. = (30,689 \times 99)-(1,860 \times 8.25 \times 49.5) = 3,200,000-760,000 = 2,440,000 \text{ in.lbs.}$$

With rear truck wheels always at point under consideration -

$$L.L.M. = \left[\left(\frac{25.25}{33} \times 15,792\right) + \left(\frac{11.25}{33} \times 3,948\right)\right] \times 99 = (12,050+1,345) \times 99 = 1,323,000 \text{ in. lbs.}$$

$$\text{Total m} = 2,440,000+1,323,000 = 3,763,000 \text{ in. lbs.}$$

$$A_s \text{ Req'd.} = \frac{3,763,000}{.899 \times 32 \times 16000} = 8.2 \text{ sq. in.}$$

Since 6-1-1/8"sq. + 1-1/4"sq. bars with a combined area of 9.16 sq.in., it is safe to take Bar B out of the bottom of the girder by bending it up.

Next Bar C is bent up at 11'-0" from the center line, and the moment must be checked at this point.

Mom. 11'-0" from center line (=6'-0" from end of girder) -

D.L.M.= (30,689x66)-(1860x5.5x33) = 2,025,000-337,500=1,687,500 in.lbs.

$$L.L.M. = \left[\left(\frac{27.5}{33} x15,792 \right) + \left(\frac{5.5}{33} x3,948 \right) \right] x66 = (13,130 + 657) x66 = 908,000 \text{ in.lbs.}$$

Total M = 2,595,500 in.lbs.

$$As\ Req'd. = \frac{2,595,500}{.899x32x16,000} = 6.43 \text{ sq.in.}$$

6-1-1/8" sq. bars, with a combined area of 7.6 sq. in. remain in the bottom of the girder to take care of the moment, when Bar C is bent up, so this point checks.

Using 5/8" ∅ stirrups, assuming that they carry 2/3 of the shear and concrete the other 1/3, the stirrup spacing is as follows -

Total shear, V, at the points checked =D.L.shear+ L.L. shear with rear truck wheels always at point under consideration.

$$\text{At 5' from end of girder,} V = (30,689)-(4.5x1,860)+\left(\frac{28.5}{33}x15,792\right)+\left(\frac{14.5}{33}x3,948\right)$$

$$= 30,689-8,370+13,600 +1,735 = 37,654 \text{ lbs.}$$

$$\text{Stirrup spacing} = \frac{A_s x j x d x f_s}{2/3\ V} = \frac{.6136x.899x32x16,000}{2/3\ V} = \frac{422,000}{V} = \frac{422,000}{37,654} = 11.2 \text{ ins. C.to C.}$$

$$\text{At 10' from end of girder,} V = (30,689)-(9.5x1,860)+\left(\frac{23.5}{33}x15,792\right)+\left(\frac{9.5}{33}x3,948\right)$$

$$= 30,689-17,650+11,250+1,135 = 25,424 \text{ lbs.}$$

$$\text{Stirrup spacing} = \frac{422,000}{25,424} = 16.5 \text{ ins. C. to C.}$$

$$\text{At 12' from end of girder,} V = (30,689)-(11.5x1,860)+\left(\frac{21.5}{33}x15,792\right)+\left(\frac{7.5}{33}x3,948\right)$$

$$= 30,689-21,400+ 10,280+ 900 = 20,469 \text{ lbs.}$$

$$\text{Stirrup spacing} = \frac{422,000}{20,469} = 20.3 \text{ ins. C. to C.}$$

In order that there might be as few different spacings as possible for stirrups to facilitate placing them during construction, the following spacings were decided upon - 12 at 12", 5 at 18", and 12 at 12", spacing to be symmetrical about center line of span.

INSIDE GIRDER

Net span = 33' = 396"

D.L.Paving = 7x.33x33x150 = 11,450 lbs.

D.L.Slab = 7x.67x33x150 = 23,250 "

D.L.Girder = 2.46x1.42x33x150 = 17,300 lbs.

Total = 52,000 lbs. (= 1,575 lbs. per ft.)

D.L. Mom. = $\frac{52000 \times 396}{8}$ = 2,575,000 in.lbs.

L.L. on inside girder = $\frac{S}{4.5}$ x wheel load, where S equals the distance c. to c. of girders (see page 16, Division III of specifications).

Hence L.L. = $\frac{7}{4.5}$ x 15,792 = 24,500 lbs. for rear wheels,

and $\frac{7}{4.5}$ x 4796 = 7,420 " " front "

With rear wheels at center of span,

L.L. React. = $(\frac{1}{2}\text{x}24{,}500) + (\frac{2.5}{33} \times 7{,}420)$ = 12,250 + 560 = 12,810 lbs.

L.L. Mom. = 12,810 x 16.5 x 12 = 2,540,000 in.lbs.

Total Mom. = 2,575,000 + 2,540,000 = 5,115,000 in.lbs.

With the outside girder designed, the "d" of the inside girder was fixed, and equal to the "d" of the outside girder plus $1\frac{1}{2}$", which is the amount of crown in the slab.

Hence "d" for the inside girder is equal to 32" + $1\frac{1}{2}$" = $33\frac{1}{2}$".

The maximum shear reaction for the inside girder at support is =

$(\frac{1}{2}$ D.L. + L.L.$)$ = $(\frac{1}{2}\text{x}52{,}000) + (24{,}500) + (\frac{19}{33} \times 7{,}420)$ = 26,000 + 24,500 + 4,270 = 54,770 lbs.

$\frac{t}{d} = \frac{8}{33.5} = .24$ Cd = 36 j = .899

(See pages 586-87 of "Concrete Plain and Reinforced", by Taylor and Thompson).

Unit Shear $= \dfrac{54,770}{.899 \times 33.5 \times 17} = 103$ lbs. sq. in. O.K.

As Required $= \dfrac{5,115,000}{.899 \times 33.5 \times 16000} = 10.5$ sq. ins.

7-1/8" sq. + 1-1/4" sq. bars (same as for outside girder were used).

The same girder bars were bent up at the same places as in the outside girder.

Then it was necessary to check the moment at the points where these bars were bent up as was done for the outside girder.

Mom. 8'-3" from center line -

D.L.M. $= (26,000 \times 99)-(1,575 \times 8.25 \times 49.5) = 2,630,000-643,000=1,987,000$ in.lbs.

L.L.M. $= \left[(\frac{25.25}{33} \times 24,500)+(\frac{11.25}{33} \times 7,420)\right] \times 99=(18,750+2,530) \times 99=2,108,000$ in.lbs.

Total M $= 4,095,000$ in. lbs.

As Required $= \dfrac{4,095,000}{.899 \times 33.5 \times 16,000} = 8.48$ sq.ins. O.K. Have area of 9.16 sq.ins.

Mom. 11'-0" from center line -

D.L.M. $= (26,000 \times 66)-(1,575 \times 5.5 \times 33)= 1,717,000-287,500= 1,429,500$ in.lbs.

L.L.M. $= \left[(\frac{27.5}{33} \times 24,500)+(\frac{13.5}{33} \times 7,420)\right] \times 66=(20,400+3,040) \times 66=1,548,000$ in.lbs.

Total M $= 2,977,500$ in.lbs.

As Req'd.$= \dfrac{2,977,500}{.899 \times 33.5 \times 16,000} = 6.17$ sq.in. O.K. Have area of 7.6 sq.in.

Using 5/8"Ø stirrups; to find spacing -

At 5' from end of girder,V$= (26,000)-(4.5 \times 1,575)+(\frac{28.5}{33} \times 24,500)+(\frac{14.5}{33} \times 7,420)$

$= 26,000-7,100+21,100+3,260 = 43,260$ lbs.

Stirrup Spacing $= \dfrac{.6136 \times .899 \times 33.5 \times 16,000}{2/3\ V} = \dfrac{442,500}{V} = \dfrac{442,500}{43,260} = 10.2$ ins.C.to C.

At 10' from end of girder, $V = (26,000)-(9.5 \times 1,575)+(\frac{23.5}{33} \times 24,500)+(\frac{9.5}{33} \times 7,420)$

$= 26,000-14,950+17,450+2,140 = 30,640$ lbs.

Stirrup Spacing $= \frac{442500}{30,640} = 14.4$ ins. C. to C.

At 12' from end of girder, $V = (26,000)-(11.5 \times 1,575)+(\frac{21.5}{33} \times 24,500)+(\frac{7.5}{33} \times 7,420)$

$= 26,000-18,120+15,970+1,690 = 25,540$ lbs.

Stirrup Spacing $= \frac{442,500}{25,540} = 17.3$ ins. C. to C.

The stirrup spacing required for the inside girder was not very different from that required for the outside girder, so the same spacing of stirrups was used for both girders.

DESIGN OF SLAB CANTILEVERED OVER OUTSIDE GIRDER

Wt. of Curb = 1x1.5x150 = 225 lbs.

" " Rail = 200x1 = 200 "

Total 425 lbs. Lever Arm = 2'-0½"

Wt. of Slab = .58x2.79x1x150 = 243 lbs. lever arm = 1'-4-3/4"

" " Paving= .33x1.29x1x150 = 64 lbs. " " = 0'-7-3/4"

D.L. Mom.= $\left[(425\times2.04)+(243\times1.39)+(64\times.64)\right]\times12=(868+338+41)\times12=14{,}950$ in.lbs.

Since the specifications require a clearance of 1'-6" from the center of the truck wheel, it is obvious that there will be no live load moment for the cantilevered slab.

Min. d req'd. = $.028\sqrt{14{,}950} = .028\times122 = 3.54$ ins.

A "d" of 6½" is available.

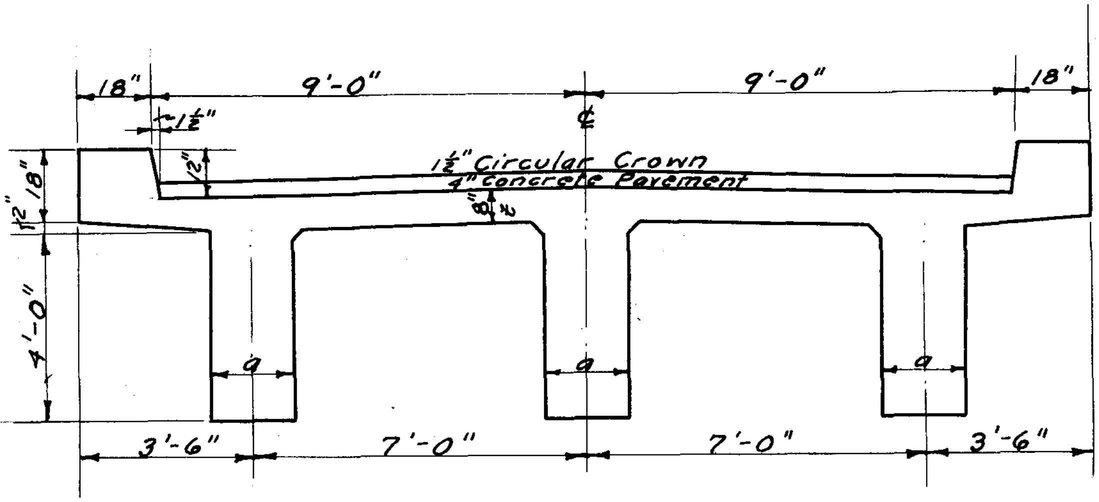
As Req'd. = .0077x3.6 = .03 sq.in.per in. of width of slab.

or .36 sq.in. per ft. of width of slab.

Bars W and Y are in the top of the slab at this point, spaced at 7" C. to C., giving .52 sq.in. of steel per ft. of width of slab.

DESIGN OF FIFTY-TWO FOOT DECK

SLAB



Assume slab thickness, t = 8"

Clear span = 5'-3" = 63"

U.D.L. Slab = .67x5.25x1x150 = 528 lbs.

U.D.L. Paving = .33x5.25x1x150=262 "

Total =790 lbs.

U.D.L. Mom. = $\frac{790x63}{10}$ = 4,980 in.lbs.

L.L. Rear Wheel = 12,000 lbs. (See slab design of 34' deck)

Impact = $\frac{50}{5.25+125}$ = 38.4%

L.L. Rear wheel + impact = (12,000)+(12,000x.384)=16,615 lbs.

Effective width = .7(2x2.63+1.25) = 4.56 ft.

L.L. per ft. of width of slab = $\frac{16,615}{4.56}$ = 3,650 lbs.

With wheel at center of span, L.L. Mom.=.205x3650x63 = 47,100 in.lbs.

Total Mom. = 4,980+47,100 = 52,080 in.lbs.

Min. d = $\sqrt{\frac{52,080}{107.5x12}}$ = $\sqrt{40.4}$ = 6.35" Make t = 8"

As Req'd. = $\frac{52,080}{.875x6.5x16,000}$ = .573 sq.ins. per ft. of width of slab

Use 5/8" ∅ at 8" C. to C.

OUTSIDE GIRDER

Net span = 51 ft. = 612 ins.

D. L. Paving = 5.42x.33x51x150 = 10,710 lbs.

D. L. Slab = 7x.67x51x150 = 35,700 lbs.

D. L. Curb = 1x1.56x51x150 = 11,930 lbs.

D. L. Girder = 4x1.75x51x150 = 53,500 lbs.

D. L. Rail = 200x 51 = 10,200 lbs.

Total =122,040 lbs.(=2,393 lbs. per lin.ft.)

D. L. Mom. = $\frac{122,040 \times 612}{8}$ = 9,325,000 in.lbs.

Live Load -

Impact = $\frac{50}{51+125}$ = 28.4%

Rear Wheel L.L. = (.4x30,000)x1.284 = 15,410 lbs.

Front Wheel L.L. = (.1x30,000)x1.284 = 3,850 lbs.

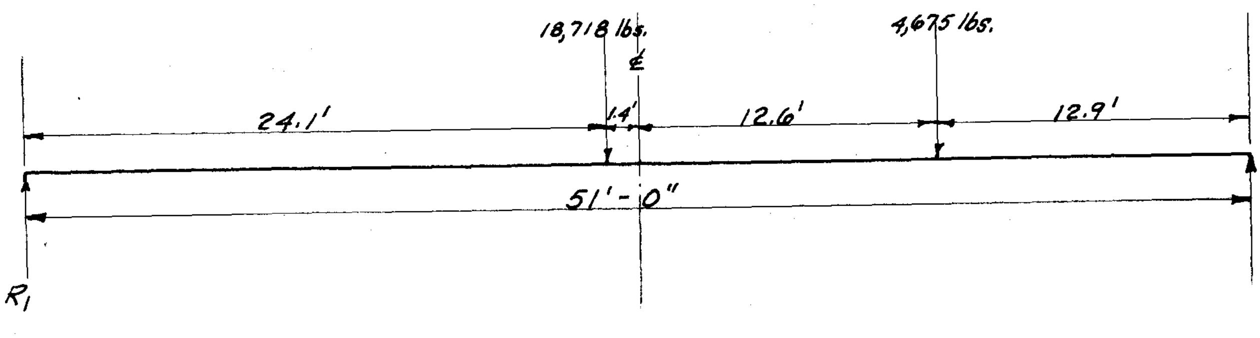
Live Load on outside girder is -

(See sketch page 22 for position of wheels)

Rear wheels = $(15,410) + (\frac{1.5}{7} \times 15,410)$ = 18,718 lbs.

Front wheels = $(3,850) + (\frac{1.5}{7} \times 3,850)$ = 4,675 lbs.

With truck wheels placed as shown below for maximum moment - (Wheels are placed so that center line of span is half the distance between the center of gravity of wheels and the heaviest load)



L. L. React. = $(\frac{26.9}{51} x18,718) + (\frac{12.9}{51} x4,675) = 9,880 + 1,180 = 11,060$ lbs.

L.L. Mom. = 11,060x24.1x12 = 3,210,000 in. lbs.

Total Mom. = 9,325,000+3,210,000 = 12,535,000 in.lbs.

Minimum d required for moment -

Assume Min.d = 42 ins.; b=84 ins.; $\frac{t}{d} = \frac{8}{42} = .19$; Cd = 32.5; j= .919

$$\text{Min. } d = \frac{12,535,000x32.5}{.919x16,000x84x8} = 41.3 \text{ ins.}$$

This checks the assumed minimum d fairly close, but, as before, it is necessary to **compute** the d required for shear.

Maximum reaction of support for shear =1/2 total D.L.+L.L. =

$(1/2x122,040) + (18,718) + (\frac{37}{51}x4,675) + (\frac{7}{51}x3/4x18,718) = 85,058$ lbs.

The absolute minimum d required for shear, allowing a unit shear of 120 lbs. per sq. in.-

$$d = \frac{85,058}{.919x120x21} = \frac{85,058}{5250} = 16.2 \text{ ins.}$$

Thus it may be noted from the above that the moment is the contolling factor for the depth of the beam.

Area of steel required for a depth of 42 ins. -

$$As = \frac{12,535,000}{.919x42x16,000} = \frac{12,535,000}{618000} = 20.3 \text{ sq. ins.}$$

The largest bar used for reinforcing is a 1-1/4" sq. To obtain 20.3 sq. in. of steel reinforcing would required 13- 1-1/4" sq.bars.

By using the calculated minimum d of 42 ins., a girder 30 ins. wide would be necessary to accommodate the 13-1-1/4" sq. bars in two layers, if the specifications were conformed to with regard to clearance between bars, cover, and etc.

By using a d of 52 ins., two layers of reinforcing of 5- 1-1/4" sq. bars each would suffice.

As required for d of 52 ins. $= \dfrac{12,535,000}{.919 \times 52 \times 16,000} = 16.4$ sq.in.

Thus we have an economical comparison between a 30"x38" (exclusive of slab d) girder and a 21"x48" girder, a difference of almost a cubic foot of concrete per ft. of girder in favor of the 21"x48" girder, to say nothing of the difference in reinforcing. Hence, the 21"x48" girder with 10-1-1/4" sq. bars was used.

Bars A, B, C, and D were trussed, for shear, as explained on page 24.

Bar A is bent up 9'-10" from the center line.

Mom. 9'-10" from center line (=16'-2" from end of girder)-

D.L.M. = $(61,020 \times 188)-(2,393 \times 15.67 \times 94) = 11,490,000-3,520,000 = 7,970,000$ in.lbs.

With rear truck wheels always at point under consideration -

L.L.M. = $\left[\left(\dfrac{35.33}{51} \times 18,718\right)+\left(\dfrac{21.33}{51} \times 4,675\right)\right] \times 188 = (12,800+1,950) \times 188 = 2,770,000$ in.lbs.

Total M = $7,970,000+2,770,000 = 10,740,000$ in.lbs.

As Req'd. $= \dfrac{10,770,000}{.919 \times 52 \times 16000} = 14.05$ sq.in.

Since 9-1-1/4" sq. bars with an area of 14.07 sq.in. are available, it is safe to bend bar A up for shear.

Bar B is bent up 12'-11" from center line.

Mom. 12'-11" from center line (=13'-1" from end of girder)

D.L.M. = $(61,200 \times 151)-(2,393 \times 12.58 \times 75.5) = 9,250,000-2,268,000 = 6,982,000$ in.lbs.

L.L.M. = $\left[\left(\dfrac{38.42}{51} \times 18,718\right)+\left(\dfrac{24.42}{51} \times 4,675\right)\right] \times 151 = (14,100+2,242) \times 151 = 2,470,000$ in.lbs.

Total M = $6,982,000+2,470,000 = 9,452,000$ in.lbs.

As Req'd. $= \dfrac{9,452,000}{.919 \times 52 \times 16,000} = 12.38$ sq.in.

With bars A and B bent up, 8-1-1/4" sq. bars with an area 12.50 sq.ins. remain for moment, which is sufficient.

Two bars C are next bent up 16'-10" from center line.

Mom. 16'-10" from center line (= 9'-2" from end of girder)

D.L.M.= (61,200x104)-(2,393x8.67x52) =6,370,000-1,078,000=5,292,000 in.lbs.

$$\text{L.L.M.} = \left[\left(\frac{42.33}{51} \times 18{,}718\right) + \left(\frac{28.33}{51} \times 4{,}675\right)\right] \times 104 = (15{,}530 + 2{,}595) \times 104 = 1{,}888{,}000'' \text{ "}$$

Total M = 5,292,000+1,888,000=7,180,000 in.lbs.

$$\text{As Rq'd.} = \frac{7{,}180{,}000}{.919 \times 52 \times 16{,}000} = 9.40 \text{ sq.ins.}$$

After bars A, B, and C are bent up, 6-1-1/4"sq.bars with an area of 9.40 sq. in. remain for moment, which is sufficient.

Two bars D are next bent up 20'-1" from center line.

Mom. 20'-1" from center line (= 5'-11" from end of girder)

D.L.M.= (61,200x65)-(2,393x5.42x32.5) = 3,980,000-421,000 =3,558,000 in.lbs.

$$\text{L.L.M.} = \left[\left(\frac{45.58}{51} \times 18{,}718\right) + \left(\frac{34.58}{51} \times 4{,}675\right)\right] \times 65 = (16{,}750 + 3{,}160) \times 65 = 1{,}294{,}000 \text{ in.lbs.}$$

Total M= 3,558,000+1,294,000 = 4,852,000 in.lbs.

$$\text{As Req'd.} = \frac{4{,}852{,}000}{.919 \times 52 \times 16{,}000} = 6.30 \text{ sq. in.}$$

After bars A, B, C, and D are bent up, 4-1-1/4" sq. bars E with an area of 6.25 sq. in. remain for moment which is sufficiently close to the area required.

Using 5/8" ∅ stirrups (see explanations under stirrups for 34 ft. deck).

$$\text{At 5' from end of girder, } V = (61{,}200) - (4.5 \times 2{,}393) + \left(\frac{46.5}{51} \times 18{,}718\right) + \left(\frac{32.5}{51} \times 4{,}675\right)$$

$$= 61{,}200 - 10{,}760 + 17{,}060 + 3{,}980 = 71{,}480 \text{ lbs.}$$

Due to the fact the depth of the girder was increased 10" above the minimum d required, the actual shear value of the concrete at 40 lbs. per sq. in. was computed, inasmuch as to assume the concrete to carry only 1/3 of the shear in computing the stirrup spacing, would not be utilizing even approximately the permissible 40 lbs. per sq.in. shear.

Shear value of girder = 40x21x.919x52 = 40,150 lbs.

Remaining shear to be carried by stirrups=71,480-40,150=31,330 lbs.

$$\text{Stirrup spacing required} = \frac{A_s f_s jd}{V} = \frac{.36\text{x}16,000\text{x}.919\text{x}52}{31,330} = \frac{468,000}{31,330} = 15 \text{ ins. C.to C.}$$

Stirrups would have to be spaced at 15 in. centers for the first five feet at least, were it not for bars A, B, C, and D, which are bent up to carry part of the shear.

The above computations have not considered them at all, although if their shear value were considered no stirrups would be needed for the first five feet.

However, it is a policy of the bridge department never to space stirrups more than 18" C. to C. Hence, in this case they were spaced at 18" centers for the entire length of the girder.

INSIDE GIRDER

Net span $=$ 51 ft. $=$ 612 ins.

D.L. Paving $= 7 \times .33 \times 51 \times 150 = 17{,}830$ lbs.-

D.L. Slab $= 7 \times .67 \times 51 \times 150 = 35{,}900$ lbs.

D.L. Girder $= 1.75 \times 4.12 \times 51 \times 150 = 55{,}000$ lbs.

Total 108,730 lbs. ($=$2,130 lbs. per lin. ft.)

$$\text{D.L. Mom.} = \frac{108{,}730 \times 612}{8} = 8{,}315{,}000 \text{ in.lbs.}$$

$$\text{Rear Wheel L.L. on inside girder} = \frac{7}{4.5} \times 15{,}410 = 24{,}000 \text{ lbs.}$$

$$\text{Front " L.L. " " "} = \frac{7}{4.5} \times 3{,}850 = 5{,}990 \text{ lbs.}$$

With wheel loads placed as for outside girder-

$$\text{L.L. React.} = \left(\frac{26.9}{51} \times 24{,}000\right) + \left(\frac{12.9}{51} \times 5{,}990\right) = 12{,}650 + 1{,}530 = 14{,}180 \text{ lbs.}$$

L.L. Mom. $= 14{,}180 \times 24.1 \times 12 = 4{,}100{,}000$ in.lbs.

Total Mom. $= 8{,}315{,}000 + 4{,}100{,}000 = 12{,}415{,}000$ in.lbs.

The depth of the inside girder is fixed by the depth of the outside girder, and is equal to 52" + 1-1/2" crown in the slab $= 53\frac{1}{2}$ ins.

With $d = 53\frac{1}{2}$ ins.; $\frac{t}{d} = \frac{8}{53.5} = .149$; $Cd = 30.5$; $j = .936$

Maximum reaction at the support for shear -

$$(\tfrac{1}{2}\text{D.L.} + \text{L.L.}) = (54{,}365) + (24{,}000) + \left(\frac{37}{51} \times 5{,}990\right) + \left(\frac{7}{51} \times \frac{3}{4} \times 24{,}000\right)$$

$$= 54{,}365 + 24{,}000 + 4{,}340 + 2{,}470 = 85{,}175 \text{ lbs.}$$

$$\text{Unit shear} = \frac{85{,}175}{.936 \times 53.5 \times 21} = \frac{85{,}175}{1{,}052} = 81 \text{ lbs. per sq.in., which is O.K.}$$

$$\text{As Req'd.} = \frac{12{,}415{,}000}{.936 \times 53.5 \times 16{,}000} = \frac{12{,}415{,}000}{802{,}000} = 15.5 \text{ sq. ins.}$$

Use 10 - 1-1/4" sq. bars, same as for outside girder.

Bars A, B, C, and D were bent up for shear at same points as in outside girder.

Bar A is bent up 9'-10" from center line.

Mom. 9'-10" from center line (=16'-2" from end of girder)

D.L.M.= (54,365x188)-(2,130x15.6x94) =10,210,000-3,135,000=7,075,000 in.lbs.

$$\text{L.L.M.}=\left[\left(\frac{35.33}{51}\times 24{,}000\right)+\left(\frac{21.33}{51}\times 5{,}990\right)\right]\times 188=(16{,}600+2{,}500)\times 188=3{,}590{,}000 \text{ in.lbs.}$$

Total M = 7,075,000+3,590,000 = 10,665,000 in.lbs.

$$\text{As Req'd.}=\frac{10{,}665{,}000}{.936\times 53.5\times 16{,}000}=\frac{10{,}665{,}000}{802000}=13.3 \text{ sq. in.}$$

As for outside girder, 9-1-1/4" sq.bars with an area of 14.07 sq.in. are available, which is sufficient.

Bar B is bent up 12'-11" from center line.

Mom. 12'-11" from center line (= 13'-1" from end of girder)

D.L.M.= (54,365x151)-(2130x12.58x75.5) =8,200,000-2,020,000=6,180,000 in.lbs.

$$\text{L.L.M.}=\left[\left(\frac{38.42}{51}\times 24{,}000\right)+\left(\frac{24.42}{51}\times 5{,}990\right)\right]\times 151=(18{,}120+2{,}870)\times 151=3{,}170{,}000 \text{ in.lbs.}$$

Total M = 6,180,000+ 3,170,000 = 9,350,000 in.lbs.

$$\text{As Req'd.}=\frac{9{,}350{,}000}{802{,}000}=11.65 \text{ sq. in.}$$

With 8-1-1/4" sq. bars having an area of 12.50 sq. in., still available for moment, this point is O.K.

Two bars C are bent up 16'-10" from center line.

Mom. 16'-10" from center line (=9'-2" from end of girder)

D.L.M.= (54,365x104)-(2130x8.67x52) =5,640,000-960,000=4,680,000 in.lbs.

$$\text{L.L.M.}=\left[\left(\frac{42.33}{51}\times 24{,}000\right)+\left(\frac{28.33}{51}\times 5{,}990\right)\right]\times 104=(19{,}660+3{,}330)\times 104=2{,}388{,}000 \text{ in.lbs.}$$

Total M = 4,680,000+2,388,000 =7,068,000 in.lbs.

$$\text{As Req'd.}=\frac{7{,}068{,}000}{802{,}000}=8.8 \text{ sq.in.}$$

6-1-1/4" sq. bars with an area of 9.4 sq. in. are still available. Hence this point is O.K.

Two bars D are bent up 20'-1" from center line.

Mom. 20'-1" from center line (=5'-11" from end of girder)

D.L.M.= (54,365x65)-(2,130x5.42x32.5) =3,530,000-376,000=3,154,000 in.lbs.

L.L.M.= $\left[\left(\frac{45.58}{51}\text{x}24{,}000\right)+\left(\frac{34.58}{51}\text{x}5{,}990\right)\right]$x65=(21480+4,060)x65=1,660,000 in.lbs.

Total M =3,154,000+1,660,000 = 4,814,000 in.lbs.

As Req'd. = $\frac{4{,}814{,}000}{802{,}000}$ = 6 sq. ins.

4-1-1/4" sq. bars "E," with an area of 6.25 sq. ins., remain available for moment; hence this joint is O.K.

Spacing of 5/8" ∅ stirrups-

At 5' from end of girder, V= (54,365)-(4.5x2,130)+$\left(\frac{46.5}{51}\text{x}24{,}000\right)$+$\left(\frac{32.5}{51}\text{x}5{,}990\right)$

=54,365-9,580+21,820+3,810 = 70,415 lbs.

Shear value of girder =40x21x.936x53.5 = 42,100 lbs.

Shear to be carried by stirrups = 70,415-42,100=28,315 lbs.

Stirrup spacing required= $\frac{A_s f_s jd}{V}$ = $\frac{.6136\text{x}16{,}000\text{x}.936\text{x}53.5}{28{,}315}$ = $\frac{492{,}000}{28{,}315}$ =17.4 ins. C.to C.

Stirrups were spaced 18" C. to C. (see note under stirrups for outside girder, page 37 .

D E S I G N   O F   D E C K 9 - 10

This is the deck that is skewed 60° with the center line on one end and with the other end at right angles to the center line of roadway.

Length of girder No. 1 $=(34)+(\frac{7.0}{\tan 60^{\circ}}) = (34)+(\frac{7.0}{1.732}) =$

$34+4.04 = 38'-0\frac{1}{2}"$

" " " No. 2 $= 34'-0"$

" " " No. 3 $= (34'0")-(4'-0\frac{1}{2}") = 29'-11\frac{1}{2}"$

It is seen that girder No. 1 is comparable to that of a 38 ft. deck, and that girder No. 3 is comparable to that of a 30 ft. deck.

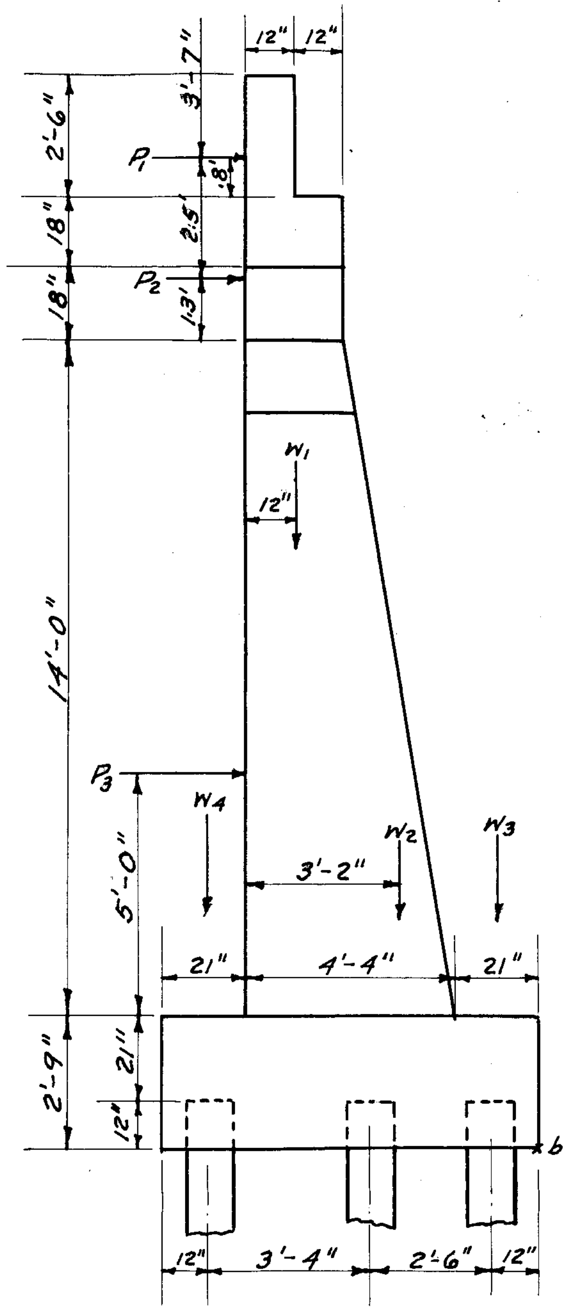
It was necessary to keep the depths of all three of the girders for deck 9-10 equal to the depth of a 34 ft. deck which preceded and followed it. Hence the depth of girder No. 1 was 3 ins. less than that required for a 38 ft. girder as shown on Georgia Standard 3502, details of decks from 22 to 38 ft. long. Therefore, it was necessary to increase bars D from 1-1/8" sq., as required for a 38 ft. deck on Standard 3502, to 1-1/4" sq.bars to make up for the lack of depth. Other bars are the same as for a 34 ft. deck.

Girder No. 2 was 34 ft. long and was standard throughout with regard to depth and reinforcing.

Girder No. 3, although only 30 ft. long, was reinforced the same as the 34 ft. girder. A slight saving could have been affected on the reinforcing for this girder, but as a measure of safety, no decrease was made in the reinforcing of this girder.

Stirrups and all other details were made the same as for the standard 34 ft. deck.

D E S I G N O F E N D B E N T



On page 10, Division III, of the specifications, it is stated that retained material shall be assumed to exert an equivalent fluid pressure of 30 lbs. per sq. ft.

Therefore, in designing the end bent, a pressure of 30 lbs. per sq. ft. against the cap was used, and 15 lbs. of pressure per sq. ft. against the columns was used. This was due to the fact that the roadway fill slopes through the columns of the end bent, and was assumed to exert a resisting pressure of 15 lbs. per sq. ft.

Area of **cap** = 62.30 sq. ft.

Area of column = 33.25 sq. ft.

Pressure = Area X unit pressure

Against parapet, P = 24.40x3.7*x30 = 2700 lbs.

" section of cap, P = 37.90 x6.2*x30 = 7100 lbs.

" column, P = 14x2x14.5*x15 = 6100 lbs.

The figures in the above equations marked with an * are the distances from the top of the fill, plus the surcharge, to the approximate center of resultant pressure. Due to the irregular shape of parapets and caps of bents, these values were determined graphically.

W_1 = (14x2x2x150)+8200(cap)	=	16,600 lbs.
W_2 = (14x2x2x110)+(14x2x2x150)	=	14,500 "
W_3 = (1.75x5x110)x19.5	=	18,700 "
W_4 = (1.75x5x110)x15	=	14,400 "
W_5 = (4.33x1.5x110)x15	=	10,700 "
W_6 = (4.33x1.5x110)x15	=	10,700 "
W_7 = (7.83x5x150)x2.75	=	16,100 "

Moms. about (b)-

P_1 = 2700x20.55 =	-55,500
P_2 = 7100x18 =	-128,000
P_3 = 6100x7.75 =	-47,300
W_1 = 16,600x5.08=	+ 84,500

$W_2 = 14{,}500 \times 1.91 = +27{,}700$

$W_3 = 18{,}700 \times .83 = +15{,}500$

$W_4 = 14{,}400 \times 6.95 = +100{,}800$

$W_5 = 10{,}700 \times 3.92 = +42{,}000$

$W_6 = 10{,}700 \times 3.92 = +42{,}000$

$W_7 = 16{,}100 \times 3.92 = +65{,}000$

$W = 101{,}700 \qquad + = +376{,}700 \qquad - = 230{,}800$

$-230{,}800$

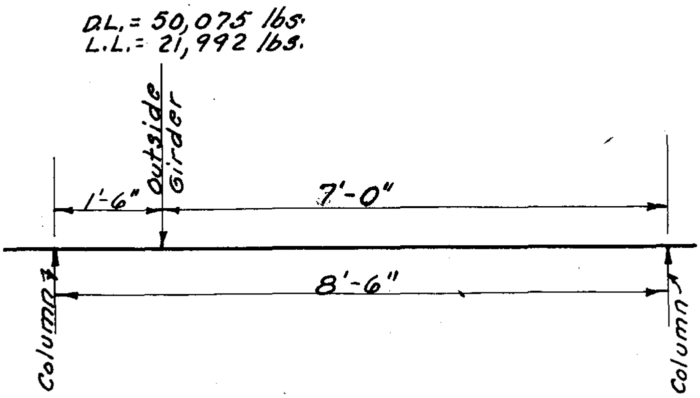
$+145{,}900 \div 101{,}700 = 1.43$

Eccentricity $= 3.92 - 1.43 = 2.49$ ft.

Max. Pressure $= \dfrac{101{,}700}{783 \times 5}\left(1 + \dfrac{6 \times 2.49}{7.83}\right) = 7566$ lbs. per sq. ft. $= 3.78$ tons per sq. ft.

Min. Pressure $= \dfrac{101{,}700}{7.83 \times 5}\left(1 - \dfrac{6 \times 2.49}{7.83}\right) = -2{,}366$ lbs. per sq. ft.

DESIGN OF CAP-



Cap is 3 ft. deep and 2 ft. wide

D.L. of cap = 3x2x8.5x150 = 7,660 lbs.

Mom. of cap = $\frac{7660\text{x}102}{10}$ = 78,200 in.lbs.

1-34' deck has 34 cu.yds. of concrete in it.

Assume 1/3 is carried by each girder,1/2 of this going to each end.

Therefore girder load = $\frac{34}{6}$ x 4000 = 27,700 lbs.

D.L. of paving to girder = 5.5x17x.33x150 = 4,675 lbs.

D.L. of rail = 34x200 = 6,800

Total girder load=39,175 lbs.

Mom.from girder D.L.react.= $\frac{7.0}{8.5}$x 39,175x1.5x12 = 419,000 in.lbs.

Girder L.L.React. =(19,172)+($\frac{20}{34}$ x4,796) =19,172+2,820 = 21,992 in.lbs.

Mom.from girder L.L.react.= $\frac{7}{8.5}$ x21,992x1.5x12= 325,800 in.lbs.

Total mom. = 78,200+419,000+21,992+325,800 = 844,992 in.lbs.

One familiar with design could readily see a cap much less than 3 ft. deep would be required for such a relatively small moment. However, a cap 3 ft. deep was used, with an effective d of 33 ins., since a smaller cap would have looked out of proportion to the superstructure.

As req'd. for d of 33" $= \frac{844,992}{.875 \times 33 \times 16000} = 1.83$ sq.ins.

2-1" sq. + 2-7/8" ∅ bars were used.

Shear at support = 3,830+41,250+18,100 = 63,180 lbs.

Unit shear $= \frac{63,180}{.875 \times 33 \times 24} = 91$ lbs. per sq. in.

As per specifications, this shear is permissable with bars trussed to carry shear. Hence, the 2-7/8"∅ bars were trussed. (See sheet number **59a**, details of piers and end bents).

Load on footings-

With 34 cu.yds. of concrete in a 34 ft. deck at 4,000 lbs. per cu.yd.

D.L.deck= 1/2x34x4000 = 68,000 lbs.

D.L.Pav.=17x18x33x150 = 15,300 lbs.

D.L.Rail= 200x17x2 = 6800 lbs.

With 33 cu.yds. of concrete in bent-

D.L.Bent = 33x400 = 132,000

L.L.React. of 2 outside girder = 21,992x2 = 43,984 lbs.

L.L. React of inside girder $=(24,500)+(\frac{20}{34}\times 7,420)=24,500+4,360=$ 28,860 lbs.

Total load = 68,000+15,300+6,800+132,000+43,984+28,860 = 294,944 lbs.

" " = 147.5 tons

As per specifications, allowable load on a foundation pile shall not exceed 15 tons.

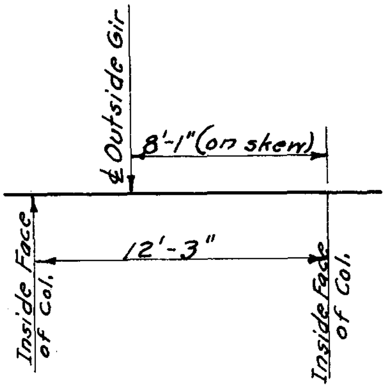
No.piles req'd. $= \frac{148}{15} = 10$

By referring to sheet **46**, it may be seen that there is theoretically no load on the rear part of the footing; hence the front four piles in the three footings, or twelve piles in all, carry the load.

To make the footings symmetrical, and as a precautionary measure, since 15 tons bearing capacity is not always obtained, 6 piles were placed under each footing.

DESIGN OF INTERMEDIATE BENTS

Bent No. 2 is a skewed bent, requiring a longer cap than bents 10, 11, 12, and 13, which are at right angles to the center line of roadway; the clear span of cap between columns for bent 2 being 12'-3", and for bents 10, 11, 12, and 13 being 9'-6".



For bent No. 2-

Span = 12'-3" = 147 ins.

D.L. beam = 12.25x3x2x150 = 11,030 lbs.

U.D.L.M. $= \frac{11,030 \times 147}{10} = 162,300$ in. lbs.

Bent No. 2 carries half of a 34 ft. deck on one side and half of a 52 ft. deck on the other side; half the weight of each deck being carried by the bent; this amount assumed to be distributed equally to the three girders.

Therefore, as before, with 34 cu.yds. of concrete in a 34 ft. deck and 77 cu.yds. of concrete in a 52 ft. deck.

D.L.34' deck Gir.React.= $\frac{1}{2}$x1/3x34x4,000 = 22,667 lbs.

D.L.52' " " " = $\frac{1}{2}$x1/3x77x4,000 = 51,333 "

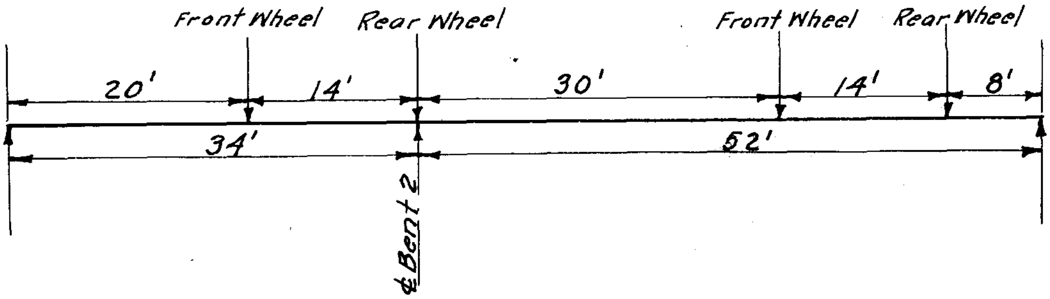
D.L.Paving both decks = (17+26)x5.5x.33x150 = 11,830 lbs.

D.L. Railing " " = (17+26)x2x200 = 17,200 lbs.

Total D.L.React.=103,030 lbs.

Mom. $= \frac{8.08}{12.25} \times 103,030 \times 50 = 3,400,000$ in.lbs.

L.L.React. to outside girder -



L.L.React. on Cap $=\left(\frac{20}{34}\times 4{,}796\right)+(19{,}172)+\left(\frac{22}{52}\times 3/4\times 4796\right)+\left(\frac{8}{52}\times 3/4\times 19{,}172\right)$

$= 2{,}820+19{,}172+1{,}520+2{,}200=25{,}712$ lbs.

L.L.Mom. $=\frac{8.08}{12.25}\times 25{,}712\times 50 = 848{,}000$ in.lbs.

Total Mom. $= 162{,}300+3{,}400{,}000+848{,}000 = 4{,}410{,}300$ in.lbs.

As for the end bent, a cap 3 ft. deep was used for appearances, giving a "d" of 33".

$$A_s \text{ req'd.} = \frac{4{,}410{,}300}{.875\times 33\times 16{,}000} = 9.5 \text{ sq.in.}$$

Use 4-1-1/4" sq. + 2-1" sq. bars

This is slightly less than the area required, but it was considered sufficient, since the loads were considered as concentrated in the calculations, when, as a matter of fact there was some degree of distribution thru the end walls at the ends of the decks which bear for their entire length on the cap.

Shear at support-

Shear $=\left(\frac{8.08}{12.25}\times 103{,}030\right)+\left(\frac{8.08}{12.25}\times 25{,}712\right) = 67{,}900+16{,}950= 84{,}850$ lbs.

Shear carried by concrete $= 33\times 24\times .875\times 40 = 27{,}700$ lbs.

" " " trussed bars $= .7\times 1.563\times 2\times 16{,}000 = 35{,}080$ lbs.

Total $= 62{,}780$ lbs.

Shear to be carried by stirrups $= 84{,}850-62{,}780= 22{,}070$ lbs.

Stirrup spacing $= \frac{A_s f_s jd}{V}$ $\frac{.314\times 16{,}000\times .875\times 33}{22{,}070} = \frac{426{,}000}{22070} = 19$ ins.C. to C.

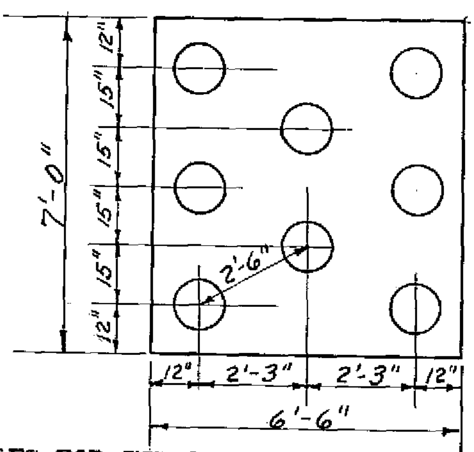
As a matter of fact these stirrups were placed 9" C. to C.

No. of piles required -

Wt. of 1/2 34' deck	= 18 cu.yds. at 4000 lbs.	=	72,000 lbs.
" " 1/2 52' deck	= 39 " " at 4000 "	=	156,000 "
" " paving	= 18'x43'x33'x150 "	=	38,700 "
" " rail	= 86'x200 lbs.	=	17,200 "
" " bent	= 15 cu.yds. at 4000 lbs.	=	60,000 "
" " " bases	= 6'x5'x2'x11x88	=	58,100 "
	Total D.L.	=	402,000 "
	Concentrated L. L.	=	42,000 "
	Uniform L.L.=900x43	=	38,700 "
	Total on both footings	=	482,700 lbs.
	Per footing	=	241,350 lbs.

No. of piles for 1 base $= \frac{241350}{30000} = 8$ piles

It will be noted by reference to the plans that no piles were shown originally. However, after construction began, suitable foundation material was not encountered and foundation piles were necessary. To obtain the spacing and cover for piles as required by the specifications, it was necessary to increase the size of the footings from 6'x5' to 6.5'x7'.



ARRANGEMENT OF PILES FOR INTERMEDIATE BENT FOOTINGS

For bents 10, 11, 12, and 13 the same procedure of design was followed as for the above bent No. 2; the only difference being that bents 10, 11, 12 and 13, which are at right angles to the center line of roadway, require a shorter cap, with a clear span between columns of 9'-6" instead of the 12'-3" for bent No. 2. This, obviously, decreased the moment produced in the cap, which in turn reduced the area of reirforcing steel required. By referring to the Plan and Elevation sheet of the plans, on which details of the intermediate bents are shown, it will be noted that bars 2 and 3 have been reduced in size from 1-1/4" sq. bars to 1" sq. bars. Other details remain the same.

DESIGN OF PIERS

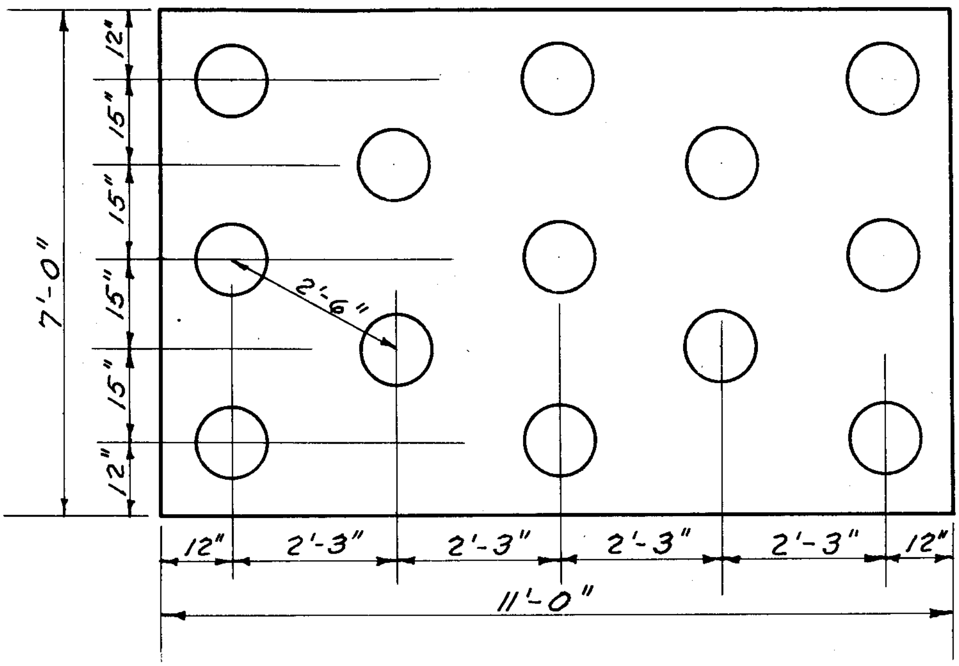
The piers were not designed in the true sense of the word, for they are what is termed as mass construction. A wall extends between the columns from the top of the footings up to the cap. Hence the cap has no unsupported length to be designed, and the question becomes a matter of drawing up a pier with proportions pleasing to the eye, and also with lines proportionate to the remainder of the bridge.

As was the case with the intermediate bents, it was necessary to drive foundation piles under all piers with the exception of pier 9, although the original plans did not call for them. To accommodate the number of piles required, the size of pier footings was increased from 7'x6' to 11'x7'.

Number of piles required for each pier -

Wt. of 1-52' Deck	=		=	312,000 lbs.
" " Paving	=	52x18x.33x150 lbs.	=	46,600 "
" " Hand Rail	=	52'x200 lbs.	=	10,400 "
" " Pier	=	38 cu.yds.at 4000 lbs.	=	152,000 "
" " Pier bases	=	7x8x2x19x88	=	188,000 "
		Total D.L.	=	709,000 "
		Concentrated L.L.	=	42,000 "
		Uniform L.L. 900x52	=	46,800 "
		Total on both footings	=	798,000 "
		Per-footing	=	399,000 "

No. of piles for 1 footing $= \frac{399000}{30000} =$ 13 piles.



ARRANGEMENT OF PILES FOR PIER FOOTING.

DESIGN OF HAND RAIL

Specifications require that hand rail shall be strong enough to resist a load of 100 lbs. per lin. ft. of unsupported length.

The distance between posts on the decks was to be approximately 10 ft.

Hence, moment to be resisted -

$$M = \frac{w\,l^2}{8} = \frac{100x\,(10)^2\,x\,12}{8} = 15,000 \text{ in. lbs.}$$

$$\text{Min. } d = .096\sqrt{\frac{15000}{8}} = .096x43.3 = 4.1611$$

Total width of rail bars is 8" with an available "d" of about 6" (See Ga. Std. No. 3602 of bridge plans).

$$\text{As Req'd.} = \frac{15,000}{.875x6x16000} = .18 \text{ sq. ins.}$$

Use 2-3/8" ø with an area of .22 sq. ins.

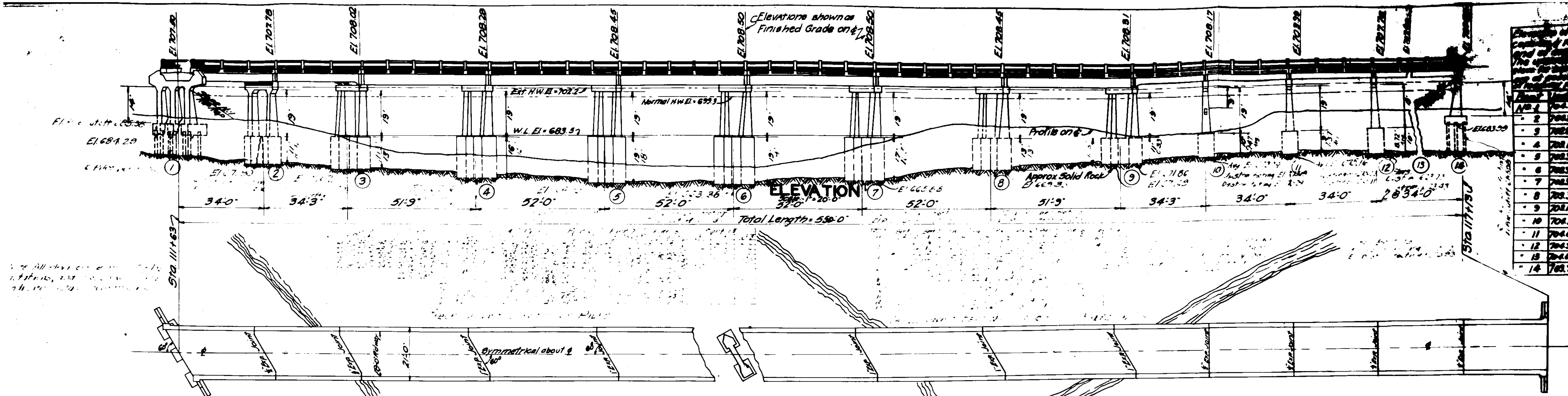
The hand rail bars are such small sections, that 4-3/8" ø bars were actually specified - two in top of rail and two in the bottom - to prevent any cracking which might occur from temperature or other stresses.

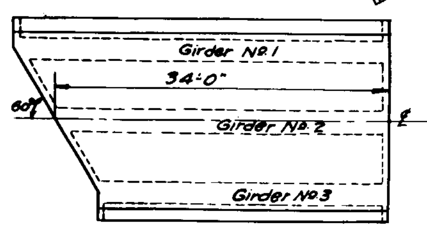
After the design was completed, the bridge was drawn up.

A parabolic camber is put in most bridges over 100 ft. long, the amount depending largely upon the type of bridge, location, and approach grades. In this case it was decided to make the finished grade at both ends of the bridge 1 foot lower than the elevation grade on deck 6-7. From the parabolic formula, $y = \frac{x^2}{p}$, where y = vertical difference from the key grade to point desired, x = horizontal distance from key grade to point desired, and $p = \frac{x^2}{y}$, x being the horizontal distance between the two points of pre-determined grade and y being the difference in elevation of the same two points, the elevations of the intermediate points as shown were calculated.

As previously explained, one additional deck was added to the East end of the bridge upon the recommendation of Mr. E. M. Arnold, Division Engineer.

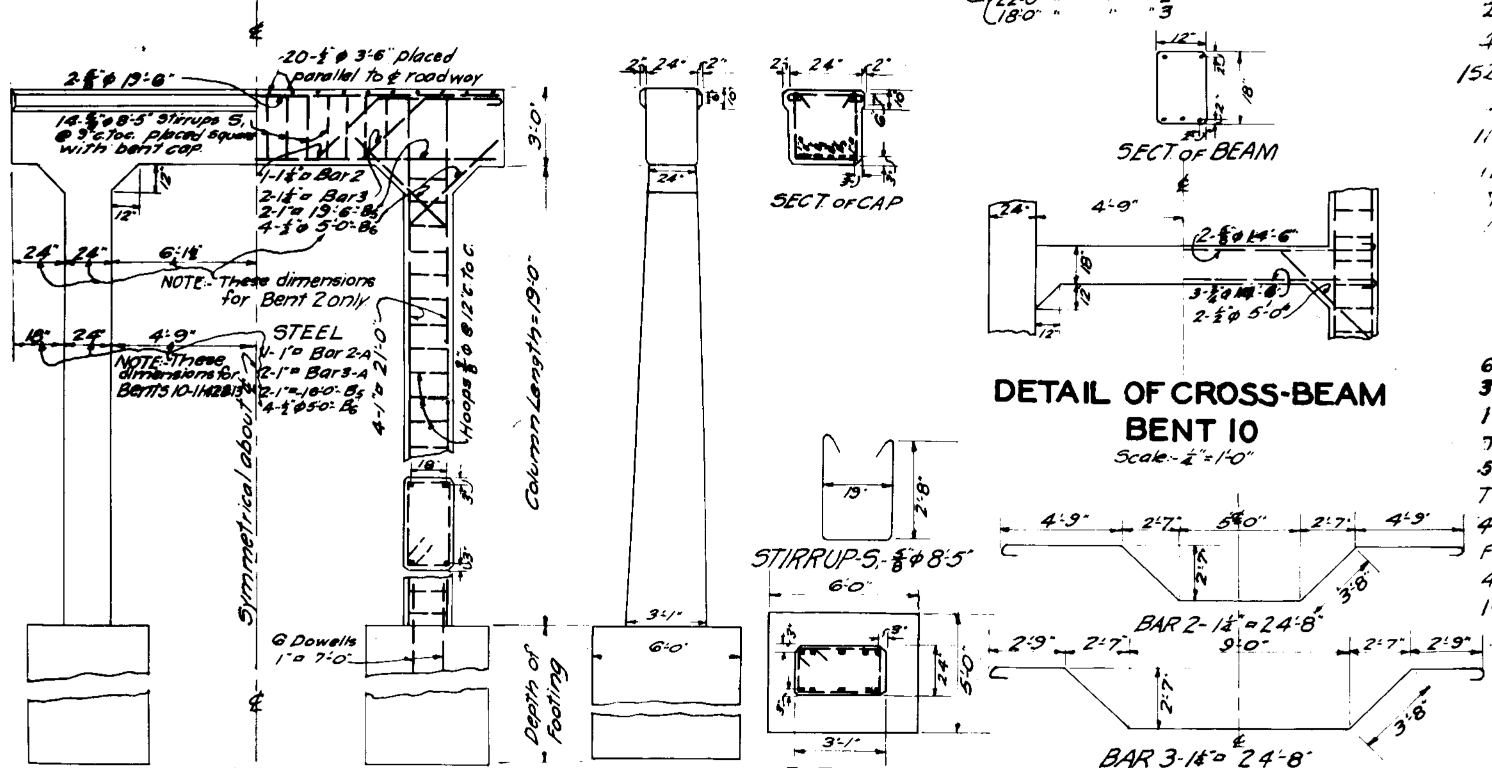
The bridge had already been detailed, with 1 ft. difference in elevation from the center of bridge to each end; so when the additional 34 ft. deck was added, the same parabolic curve was just continued for another 34 ft. This made the East end of the bridge 1.3 ft. lower than the highest elevation of finished grade on the bridge, and 0.3 of a foot lower than the West end of the bridge.





DETAILS OF DECK BETWEEN BENTS 9&10

For further details see Ga. Stds. Nºs 68 & 68-5
Scale-1"=10'-0"



DETAIL OF CROSS-BEAM BENT 10

Scale-½"=1'-0"

NOTE-The above dimensions and sizes of Bars 2&3 are for Bent 2 only.

DETAILS OF INTERMEDIATE BENTS 2-10-11-12 & 13

Scale-¼"=1'-0"

SUMMARY OF QUANTITIES

840 CU.YDS. CLASS "A" CONCRETE
262 CU.YDS. CLASS "B" CONCRETE-PIER SHAFTS.
448 CU.YDS. CLASS "B" CONCRETE-PIER & INTER. BENTS BASES
152,000 LBS. REINFORCING STEEL.
540 LIN.FT. FOUNDATION PILES-
1100 LIN.FT. TYPE "F" HANDRAILING.
1100 SQ.YDS. 4" CONCRETE PAVING.
787 CU.YDS. EXCAVATION NO. 1.
157 CU.YDS. EXCAVATION No. 2 (IF REQ'D).

BRIDGE CONSISTS OF:-

6-52'-0" DECKS-SKEWED 60° ----- GA. STD. Nº 40 & 68-5
3-34'-0" DECKS- ----- 68 & 68-5
1-END BENT Nº1- ----- SEE SPECIAL DESIGN.
7-INTER. PIERS- -----
5-INTER. BENTS- ----- THIS SHEET.
TYPE "F" HANDRAILING -------- GA. STD. Nº 54.
4" CONCRETE PAVING.
FOUNDATION PILING- ESTIMATED 15' LONG
4-34'-0" DECKS----- GA. STD. Nº 68.
1-END BENT Nº 14--- " " 69.

DRAINAGE DATA

DRAINAGE AREA=1160 SQ. MILES.
AREA OF OPENING UNDER H.W.=8930□'.

GENERAL NOTES

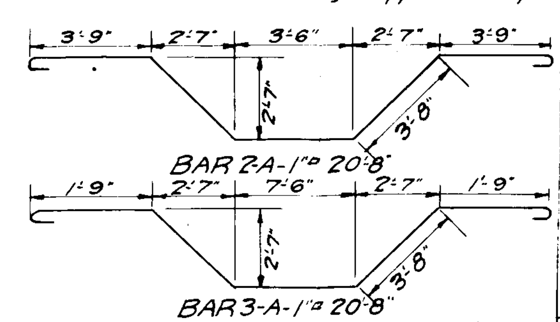
SPECIFICATIONS:- Georgia Standard for Bridges.

MATERIALS:- Decks and Bents---Class "A" Concrete 1:6 mix.
Handrailing------Class "D" Concrete 1:5 mix.
4" Concrete Paving---Class "A" Concrete 1:5 mix.
Pier shafts-------Class B Concrete 1:7½ mix.
Pier & inter. bent bases, if poured dry-Class "B" Concrete 1:7½ mix.
Pier & inter bent bases, if poured wet-Class "A" Concrete 1:6 mix.
Reinforcing of steel bars.

CONSTRUCTION:- All concrete for one deck must be poured continuously.
No construction joint permitted between girders, slab and curbs.
Expansion joints of asphalt and felt formed thus — Expansion Mater.
Chamfer all exposed edges ¾" unless noted.
Excavation Nº 1:- To bottom of footings as shown.
Excavation Nº 2:- Below bottom of footings as shown (if req'd).
Bottom of footings shown approximate only. Carry all foundations to depths satisfactory to engineer.
Untreated foundation piles estimated 15' long.
Forms for railing and curbs to be of dressed lumber at least 2" thick.

FINISH:- Top, inside and outside of curbs, brackets and railing to have rubbed fin.
Other parts spade finish. Remove excessive form marks.
True up surface of slab with template and float.

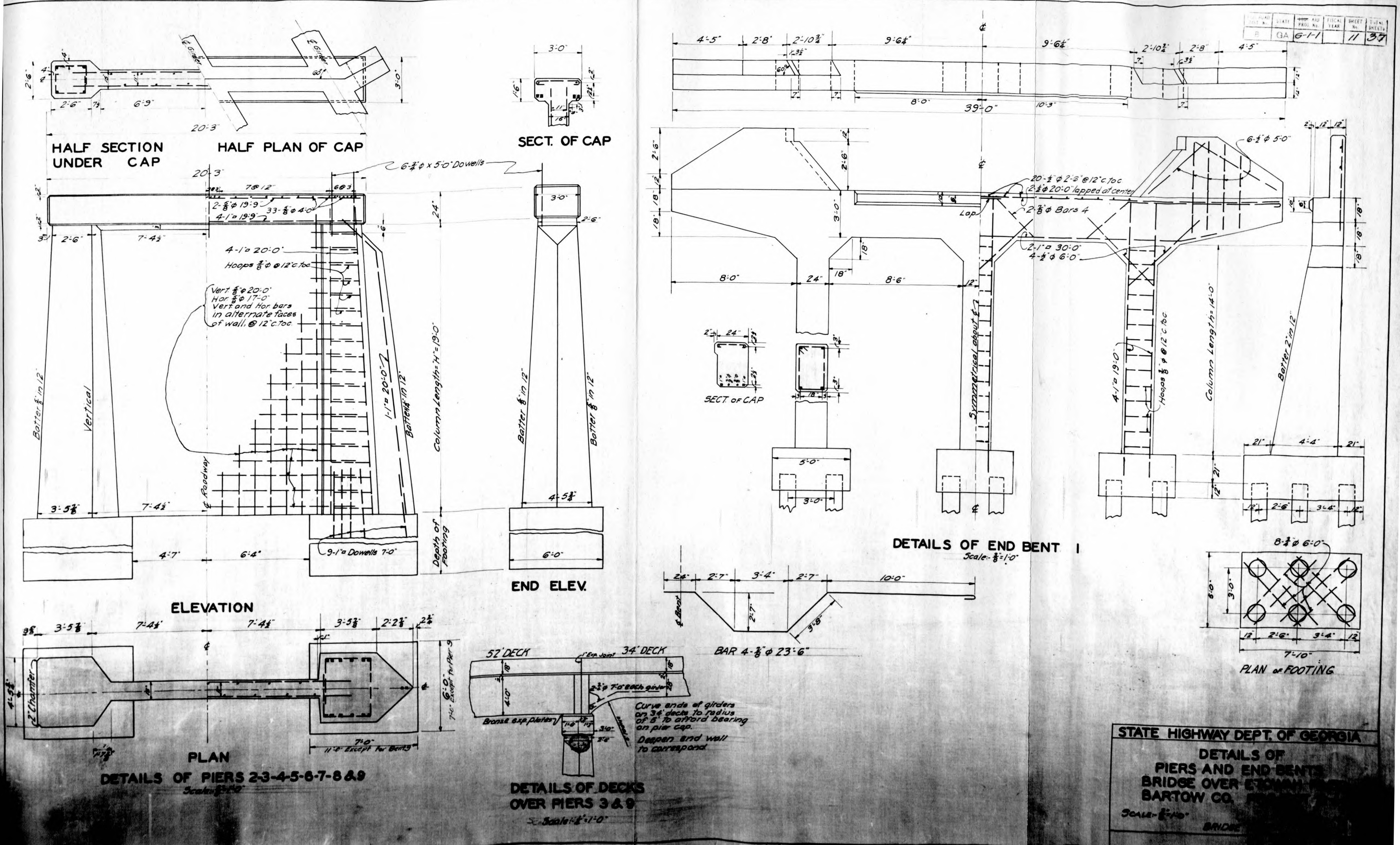
RIP-RAP:- Riprap slopes thoroughly. Grouted riprap drains provided at both ends of bridge. Riprap and grouted drains to be placed by roadway contractor.
Omit drain holes in decks directly over riprapped slopes.
Old bridge approximately 800 feet downstream from proposed bridge.



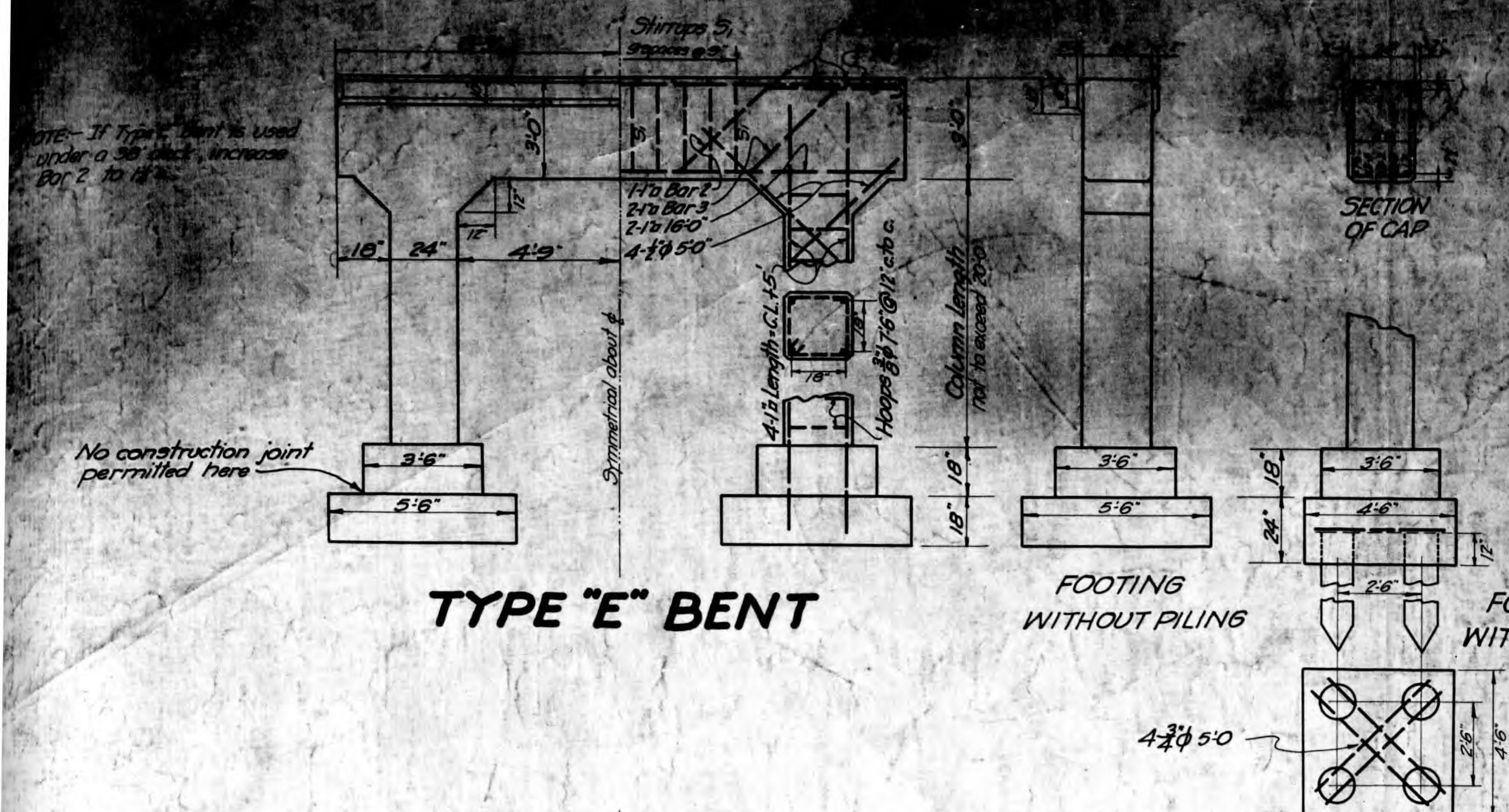
NOTE-The above dimensions and sizes of bars 2A & 3-A are for Bents 10-11-12 & 13.

STATE HIGHWAY DEPT. OF GEORGIA
DESIGN OF
BRIDGE OVER ETOWAH RIVER
BARTOW CO. PROJ. G-
STA. 111+63 TO STA. 117+13

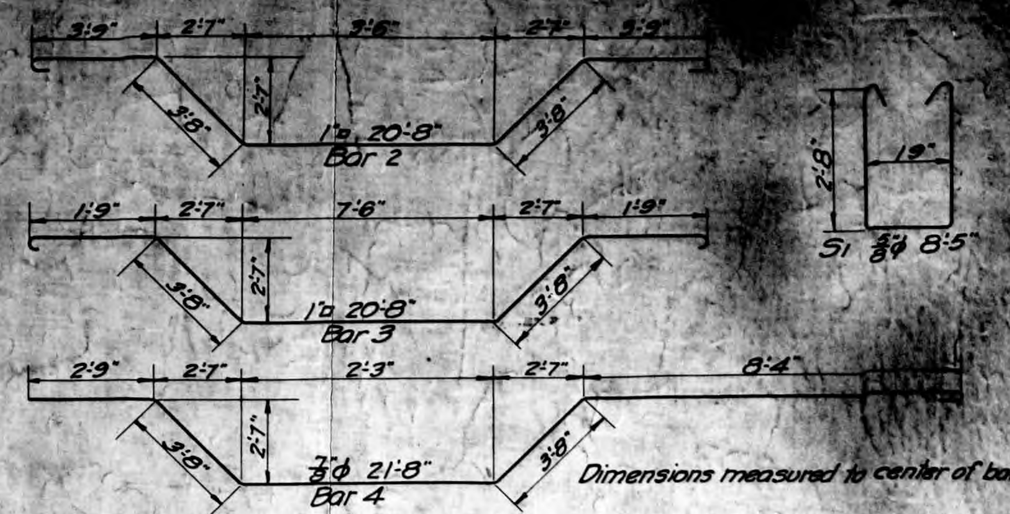
SCALES AS SHOWN
Nov.-1926.
BRIDGE DEPT.



B | GA | G-1-1 | 11 | 37
HALF SECTION UNDER CAP
HALF PLAN OF CAP
SECT. OF CAP
6-3/4"φ x 5'-0" Dowells
4-1"□ 20'-0"
Hoops 3/8"φ @ 12" c. to c.
Vert. 5/8"φ 20'-0"
Hor. 5/8"φ 17'-0"
Vert and Hor. bars in alternate faces of wall, @ 12" c. to c.
Column Length "H" = 19'-0"
Batter 1/2" in 12"
Batter 1/8" in 12"
Vertical
℄ Roadway
9-1"□ Dowells 7'-0"
Depth of Footing
ELEVATION
END ELEV.
2" Chamfer
PLAN
DETAILS OF PIERS 2-3-4-5-6-7-8 & 9
52' DECK
34' DECK
Bronze exp. plates
Curve ends of girders on 34' decks to radius of 8" to afford bearing on pier cap.
Deepen end wall to correspond.
DETAILS OF DECKS OVER PIERS 3 & 9
Scale: 1/4" = 1'-0"
39'-0"
20-1/2"φ 2'-6" @ 12" c. to c.
2-3/4"φ 20'-0" lapped at center
Lap
2-3/4"φ Bars 4
2-1"□ 30'-0"
4-1/2"φ 6'-0"
6-1/2"φ 5'-0"
SECT. OF CAP
Symmetrical about ℄
4-1"□ 19'-0"
Hoops 3/8"φ @ 12" c. to c.
Column Length = 14'-0"
Batter 2" in 12"
DETAILS OF END BENT 1
Scale: 3/8" = 1'-0"
BAR 4-7/8"φ 23'-6"
8-3/4"φ 6'-0"
PLAN OF FOOTING
STATE HIGHWAY DEPT. OF GEORGIA
DETAILS OF PIERS AND END BENTS
BRIDGE OVER ETOWAH
BARTOW CO.
Scale: 3/8" = 1'-0"



TYPE "E" BENTS			
QUANTITIES			
LIST OF BARS FOR 1 BENT			
Pieces	Size	Length	Location
2	½"φ	16'-0"	Top of Beam
16	½"φ	2'-6"	"
1	1"□	20'-8"	Bar 2
2	1"□	20'-8"	Bar 3
2	1"□	16'-0"	Bot. of Beam
8	½"φ	5'-0"	2-Brackets
10	⅜"φ	8'-5"	Stirrups S_1
8	1"□	Col. L+5'-0"	2-Columns
2×Col. L	⅜"φ	7'-6"	2-Cols. Hoops
8	¾"φ	5'-0"	2-Footings with piles.
Weight of steel except columns with piles		678 Lbs.	
no piles		618 Lbs.	
Steel in 2 columns		33 Lbs. per ft.	
Volume of cap		3.95 cu. yds.	
Vol. of foots with piles		4.36 cu. yds.	
no piles		4.72 cu. yds.	
Vol. 2 cols. per foot		0.296 cu. yds.	

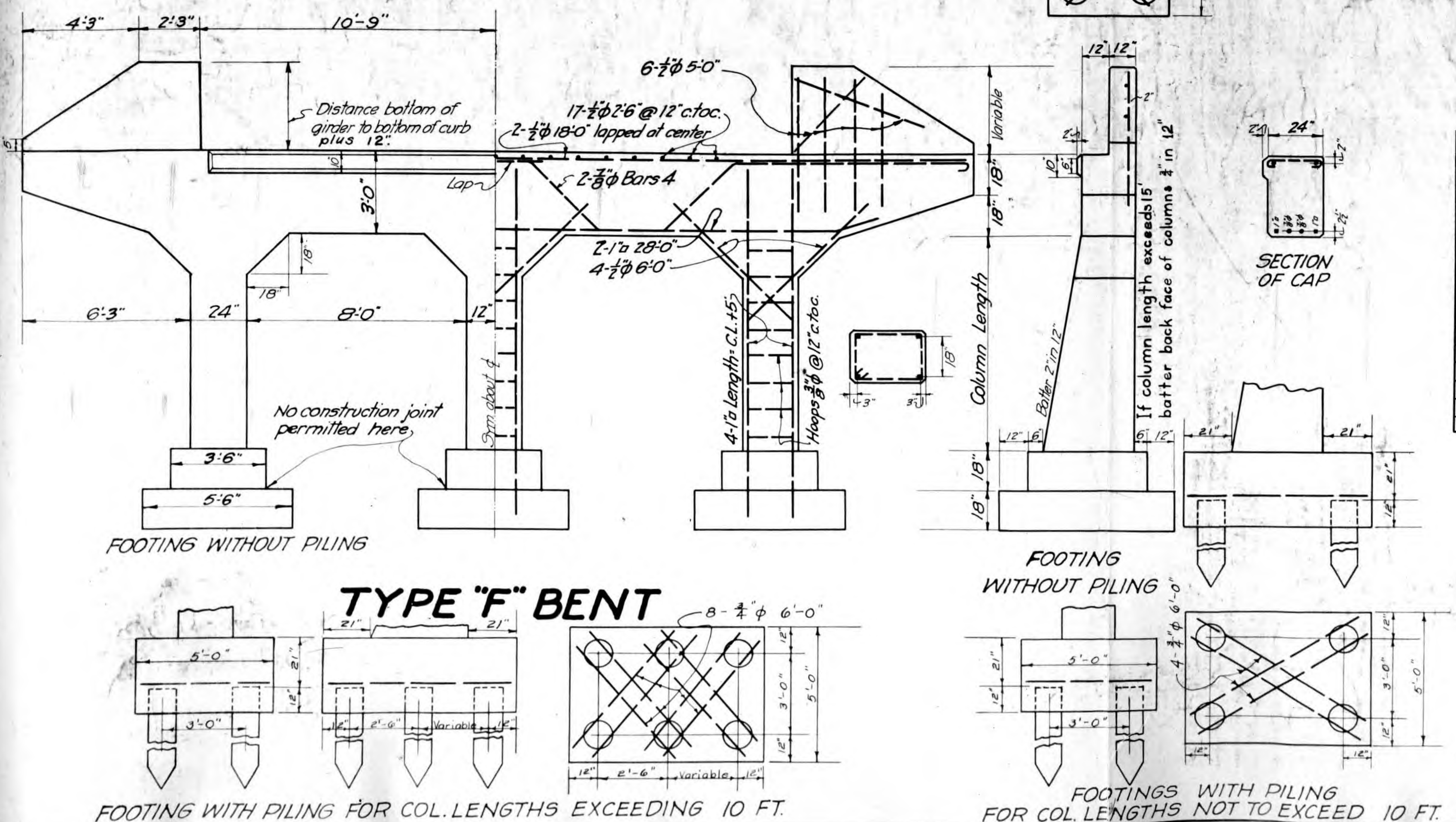


GENERAL NOTES

SPECIFICATIONS:- Georgia Standard for Bridges.

MATERIALS:- Concrete - Class "A" 1:6 Mix. Reinforcement of steel Bars.

FINISHES:- Trowell top of cap or beam. Columns, spade finish. Remove excessive form marks. Chamfer all exposed edges ¾".



QUANTITIES TYPE "F" BENTS

Volume of Cap 8.93 cu. yds.

Steel except in Cols. 632 lbs. with piles - C.L. to 10'; 740 lbs. with piles - C.L. over 10'; 524 lbs. no piles.

Hoops for 3 Columns — ⅜"φ 3 Bars each Length

Col. L. Feet															
4	7'-6"	7'-10"	8'-2"	8'-6"											
5	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"										
6	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"									
7	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"	9'-6"								
8	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"	9'-6"	9'-10"							
9	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"	9'-6"	9'-10"	10'-2"						
10	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"	9'-6"	9'-10"	10'-2"	10'-6"					
11	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"	9'-6"	9'-10"	10'-2"	10'-6"	10'-10"				
12	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"	9'-6"	9'-10"	10'-2"	10'-6"	10'-10"	11'-2"			
13	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"	9'-6"	9'-10"	10'-2"	10'-6"	10'-10"	11'-2"	11'-6"		
14	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"	9'-6"	9'-10"	10'-2"	10'-6"	10'-10"	11'-2"	11'-6"	11'-10"	
15	7'-6"	7'-10"	8'-2"	8'-6"	8'-10"	9'-2"	9'-6"	9'-10"	10'-2"	10'-6"	10'-10"	11'-2"	11'-6"	11'-10"	12'-2"

Col. L. Feet	Vertical Col. Steel 1"□ 12 each Length	Volume of 3 Cols. Cu. Yds.	Steel in 3 Cols. Lbs.	Volume of 3 Footings With Piles	Volume of 3 Footings No Piles	Total Quantities 1-Bent With Piles Conc. Cu. Yds.	With Piles Steel - Lbs.	No Piles Conc. Cu. Yds.	No Piles Steel - Lbs.	Col. L. Feet
4	9'-0"	2.08	403	9.43	7.33	20.44	1035	18.34	927	4
5	10'-0"	2.68	454	9.67	7.58	21.28	1086	19.19	978	5
6	11'-0"	3.33	505	9.93	7.83	22.19	1137	20.09	1029	6
7	12'-0"	4.02	557	10.19	8.08	23.14	1189	21.03	1081	7
8	13'-0"	4.74	609	10.43	8.33	24.10	1241	22.00	1133	8
9	14'-0"	5.50	661	10.69	8.58	25.12	1293	23.01	1185	9
10	15'-0"	6.30	714	10.95	8.83	26.18	1346	24.06	1238	10
11	16'-0"	7.13	767	11.20	9.08	27.26	1507	25.14	1297	11
12	17'-0"	8.00	820	11.46	9.33	28.39	1560	26.26	1344	12
13	18'-0"	8.92	874	11.72	9.58	29.57	1614	27.43	1398	13
14	19'-0"	9.85	928	11.96	9.83	30.75	1668	28.61	1452	14
15	20'-0"	10.83	982	12.22	10.08	31.98	1722	29.84	1506	15

Column reinforcing and design similar for other column lengths.

TYPE "F" BENTS			
LIST OF BARS FOR 1-BENT			
Pieces	Size	Length	Location
12	½"φ	5'-0"	Wings
4	½"φ	18'-0"	Top of Beam
17	½"φ	2'-6"	" " "
4	⅞"φ	20'-8"	Bar 4
2	1"□	28'-0"	Bot. of Beam
12	½"φ	6'-0"	3-Brackets
12	1"□	Col. L.+5'-0"	3-Columns
3×Col. L	⅜"φ	See table above	3-Col. Hoops
12	¾"φ	6'-0"	3-Footings with piles C.L. to 10'
24	¾"φ	6'-0"	3-Footings with Piles, C.L. over 10'

OLD No. 69

HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DEPARTMENT — ATLANTA

STANDARD CONCRETE BENTS

18'-0" ROADWAY

Scale:- ⅜" = 1'-0" Oct. 1923

This plan to be used with Ga. Standard No. 3502

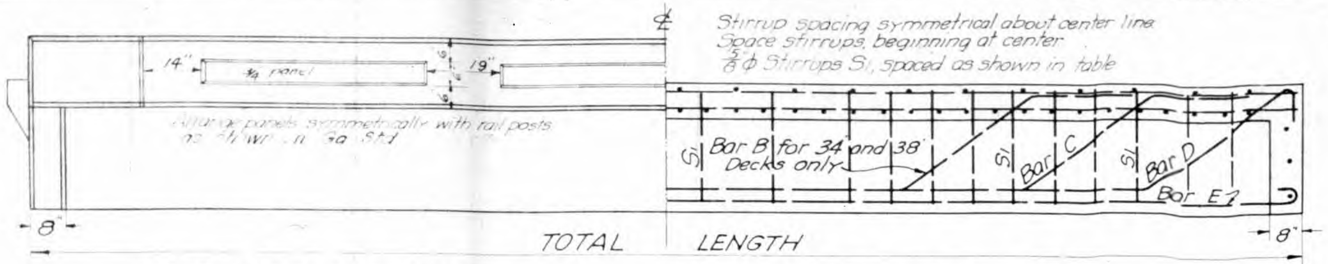
Designed C.N.C.
Traced C.N.C.
Checked S.B.S.
Revised 3-21-25 C.N.C.
11-28-28

Submitted Searcy B. Slack, Bridge Engineer

Approved [signature], State Highway Engineer

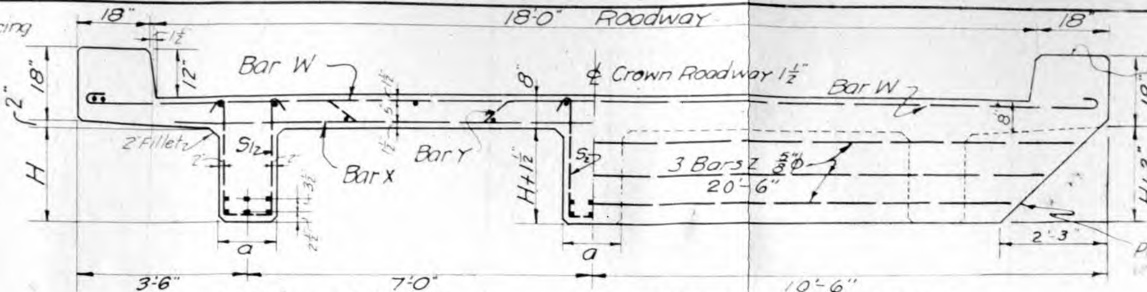
NO. 3203

FED ROAD DIST NO	STATE	STATE AID PROJ NO	FED AID PROJ NO	FISCAL YEAR	SHEET NO	TOTAL SHEETS
8	GA					

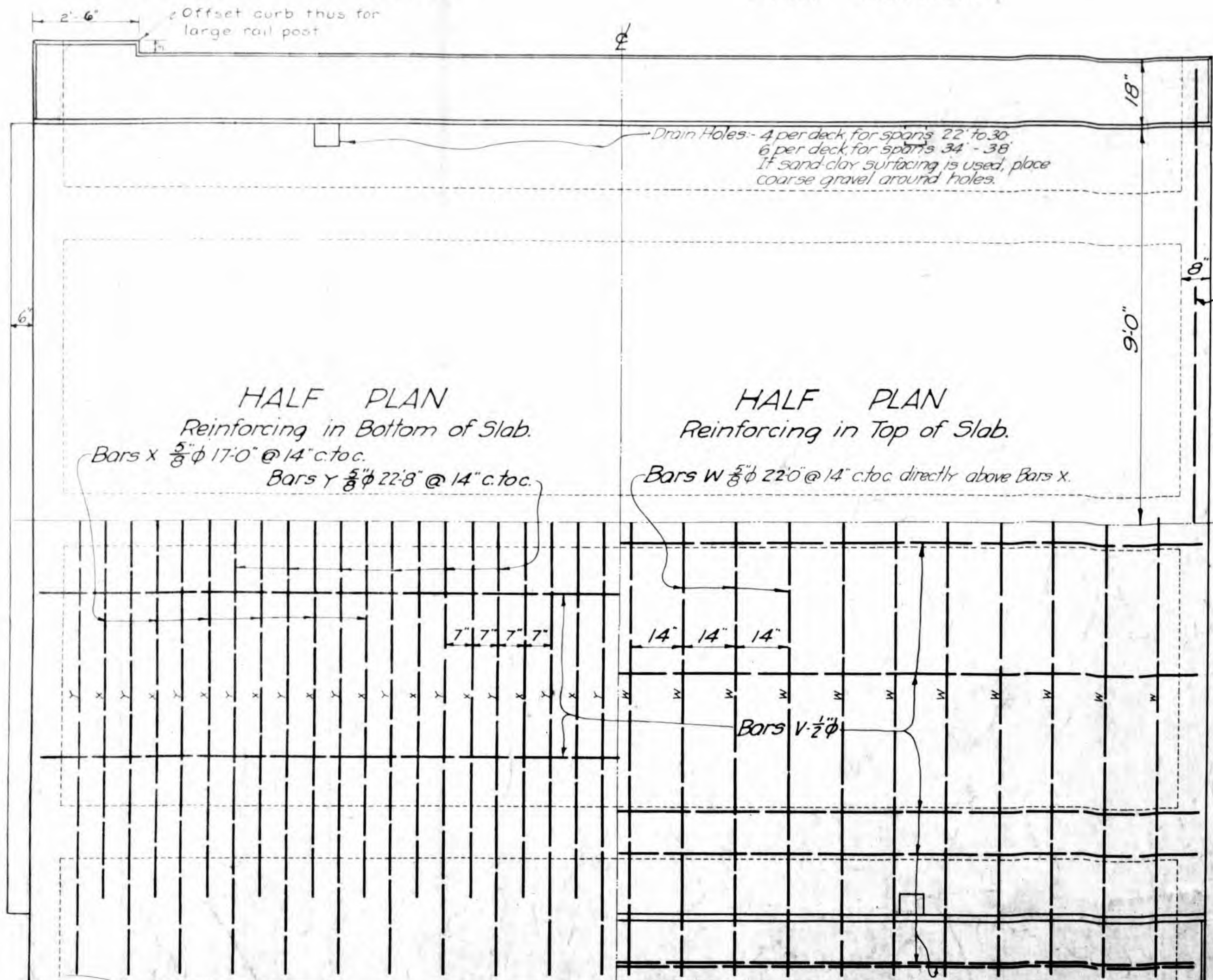


HALF SIDE ELEVATION HALF SECTION

See rail details for placing rail steel in curbs.

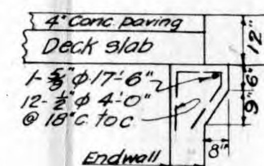


HALF SECTION HALF END ELEVATION



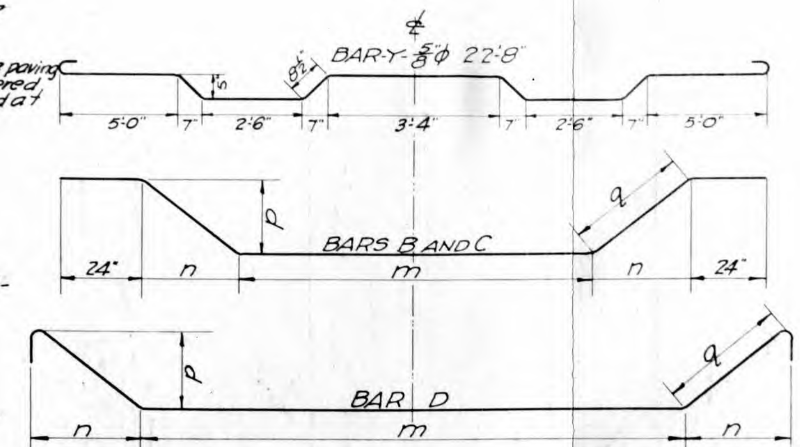
HALF PLAN
Reinforcing in Bottom of Slab.

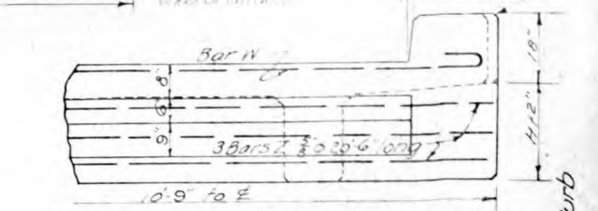
HALF PLAN
Reinforcing in Top of Slab.



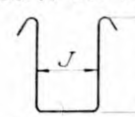
DETAILS OF BRACKET ON END DECKS TO SUPPORT FUTURE PAVING SLAB.

QUANTITIES FOR 1 BRACKET:-
.389 Cu. Yds. Class "A" Concrete
50 Lbs. Reinforcing Steel.

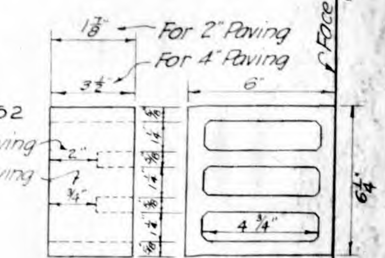




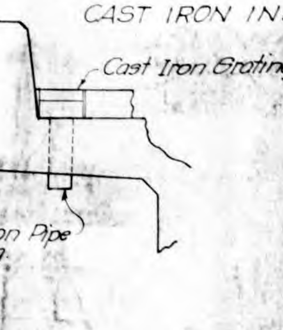
DETAIL AT ENDS OF BRIDGE



STIRRUP S1 & S2 5/8 φ



CAST IRON INLET



DRAIN HOLE DETAIL
Scale:- 1"=1'-0"

DIMENSIONS FOR BENDING BARS

Length of Deck	BAR B n	BAR B m	BAR B p	BAR B q	BAR C n	BAR C m	BAR C p	BAR C q	BAR D n	BAR D m	BAR D p	BAR D q	STIRRUPS Length	STIRRUPS J	S1 K	S2 K
22'	—	—	—	—	1'-11"	12'-4"	21"	2'-7"	1'-11"	17'-4"	21"	2'-7"	6'-5"	12"	2'-1½"	2'-3"
24'	—	—	—	—	2'-2"	14'-0"	23"	2'-11"	2'-2"	19'-0"	23"	2'-11"	6'-9"	12"	2'-3½"	2'-5"
25'	—	—	—	—	2'-2¼"	15'-0"	23"	2'-11"	2'-2½"	19'-10"	23"	2'-11"	6'-9"	12"	2'-3½"	2'-5"
26'	—	—	—	—	2'-3"	15'-8"	23"	2'-11½"	2'-3"	20'-8"	23"	2'-11½"	6'-10"	13"	2'-3½"	2'-5"
30'	—	—	—	—	2'-7"	19'-0"	2'-1"	3'-4"	2'-7"	24'-0"	2'-1"	3'-4"	7'-2"	13"	2'-5½"	2'-7"
34'	2'-11"	16'-6"	2'-4"	3'-9"	2'-11"	22'-0"	2'-4"	3'-9"	2'-11"	27'-4"	2'-4"	3'-9"	7'-8"	13"	2'-8½"	2'-10"
38'	3'-2"	19'-0"	2'-7"	4'-1"	3'-2"	25'-0"	2'-7"	4'-1"	3'-2"	30'-10"	2'-7"	4'-1"	8'-6"	17"	2'-11½"	3'-1"

GENERAL NOTES AND DESIGN DATA

Specifications............Ga. Standard for Bridges.
Concentrated Load.........Typical 15 ton trucks.
Impact....................30% of live load.
Paving..............not to exceed 50 lbs. per sq. ft.

Chamfer all exposed edges ¾" unless noted.
For detail of railing, see Ga. Standard.
Expansion joints of asphalt and felt, formed thus:

Each deck to be poured continuously.
No construction joint permitted between girders, slab and curb.

Finishes:- Top of curb trowelled. Inside and outside of curbs rubbed. Other parts spade finish. Remove excessive form marks.
True up surface of slab with template and float.

MATERIALS
Concrete........Class "A" 1:6 mixture.
Aggregate.......Max. diameter 1½ inches.
Reinforcing.....Steel bars.

TOTAL LENGTH Feet	Depth "H"	Width "a"	Bar B	Bar C	Bar D	Bar E	Stirrups S1, S2	Stirrup Spacing	Bar W 5/8φ 22'-0"	Bar X 5/8φ 17'-0"	Bar Y 5/8φ 22'-8"	Bar V 16-½φ	Bar Z 5/8φ	VOLUME CONCRETE Cu. Yds.	TOTAL STEEL Pounds	TOTAL LENGTH Feet
22	21"	16"	—	3-1"□-21'6"	6-1"□-24'-10"	9-1⅛"□-24'-0"	60-5/8φ-6'-5"	8 @ 12" 3 @ 18" 8 @ 12"	18	18	18	21'-6"	2@19'-6" 2@18'-0" 2@16'-6"	20.96	3575	22
24	23"	16"	—	3-1"□-23'-10"	6-1"□-27'-2"	9-1¼"□-26'-4"	60-5/8φ-6'-9"	7 @ 12" 5 @ 18" 7 @ 12"	19	19	20	23'-6"	2@19'-6" 2@18'-0" 2@16'-6"	23.29	4109	24
25	23"	16"	—	3-1⅛"□-24'-10"	6-1⅛"□-28'-2"	9-1⅛"□-27'-0"	72-5/8φ-6'-9"	9 @ 11" 5 @ 18" 9 @ 11"	20	20	21	24'-6"	2@19'-6" 2@18'-0" 2@16'-6"	24.20	4309	25
26	23"	17"	—	3-1⅛"□-25'-7"	6-1¼"□-29'-5"	9-1⅛"□-28'-0"	72-5/8φ-6'-10"	9 @ 11" 5 @ 18" 9 @ 11"	21	21	21	25'-6"	2@19'-6" 2@18'-0" 2@16'-6"	25.75	4626	26
30	25"	17"	—	6-1⅛"□-29'-8"	6-1⅛"□-33'-2"	12-1⅛"□-32'-0"	90-5/8φ-7'-2"	12 @ 10" 5 @ 18" 12 @ 10"	24	24	25	29'-6"	2@19'-6" 2@18'-0" 2@16'-6"	30.22	5970	30
34	28"	17"	3-1⅛"□-28'-0"	3-1¼"□-33'-6"	6-1⅛"□-37'-4"	12-1⅛"□-36'-0"	90-5/8φ-7'-8"	12 @ 12" 5 @ 18" 12 @ 12"	28	28	28	33'-6"	2@19'-6" 2@18'-0" 2@[illegible]	35.57	[illegible]	34
38	31"	21"	3-1⅛"□-31'-2"	6-1⅛"□-37'-2"	6-1⅛"□-41'-6"	15-1⅛"□-40'-0"	96-5/8φ-8'-6"	11 @ 12" [illegible] 11 @ 12"	31	31	[illegible]	[illegible]	[illegible]	44.82	[illegible]	38

Note:- Cast iron inlets and drain pipes will be paid for [illegible] reinforcement.

OLD No. 68

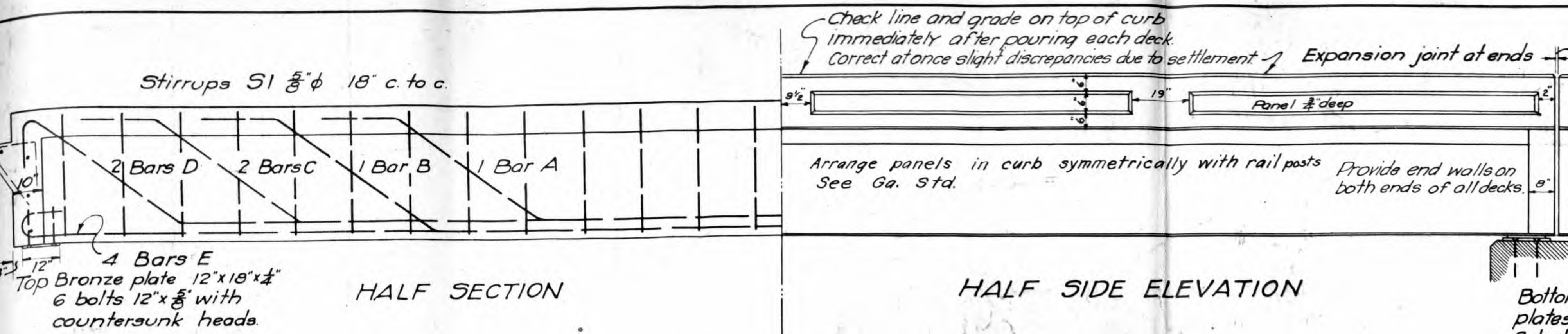
HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DEPARTMENT — ATLANTA

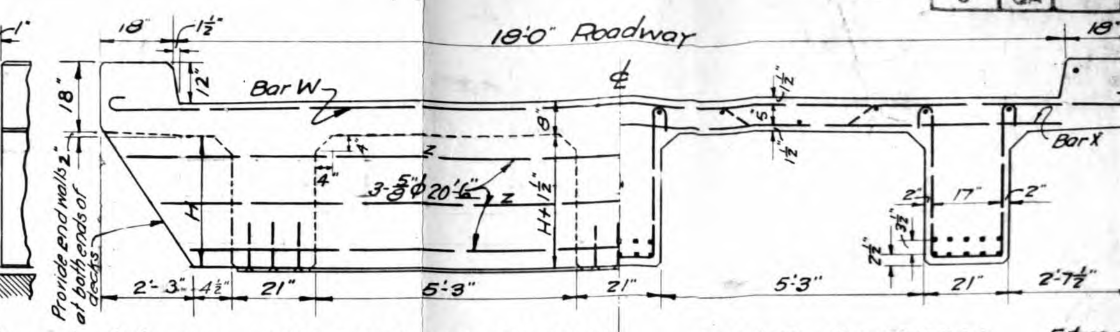
CONCRETE BRIDGE DECKS
LENGTHS 22'-0" TO 38'-0"
18'-0" ROADWAY

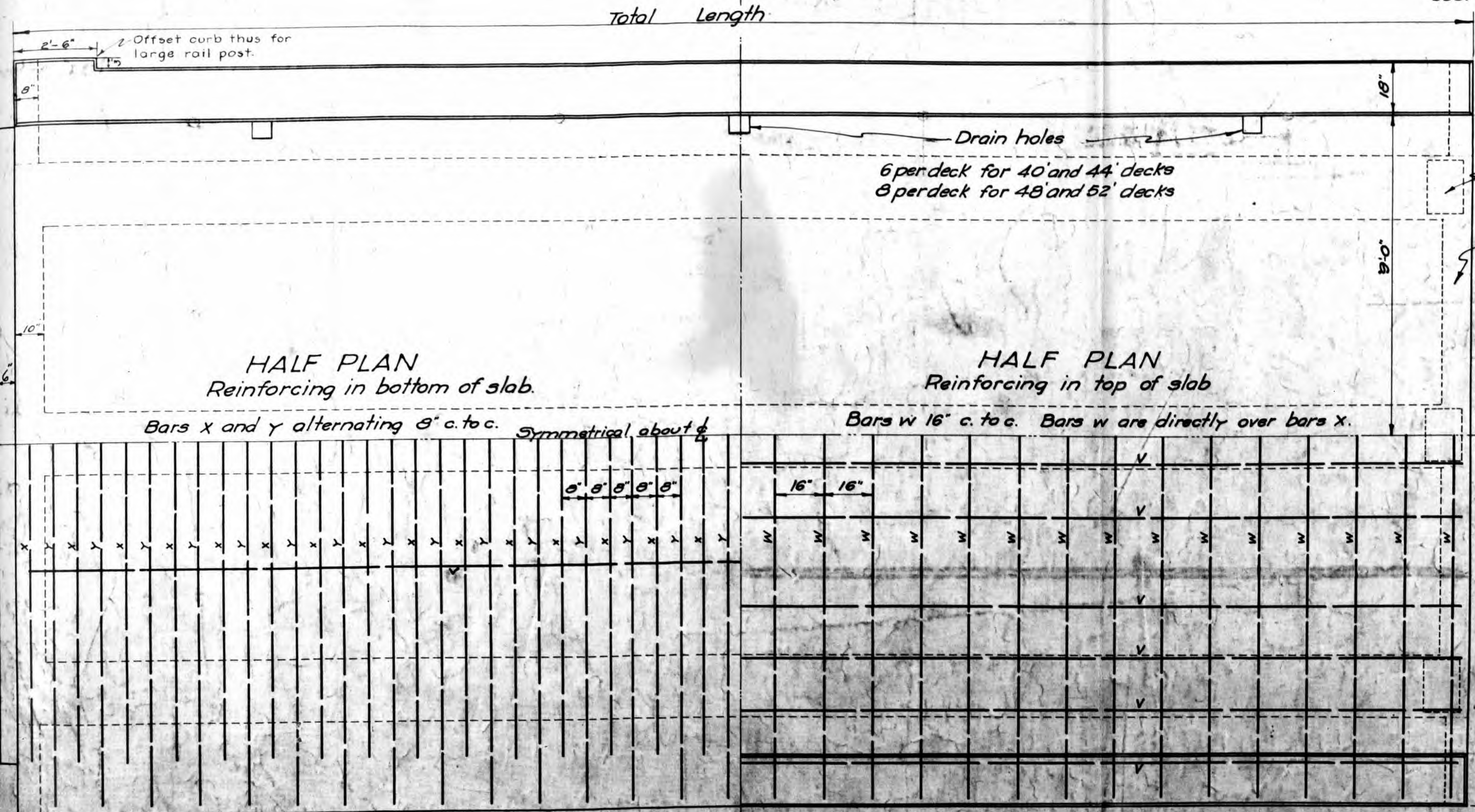
No Scale. Sept.-1923

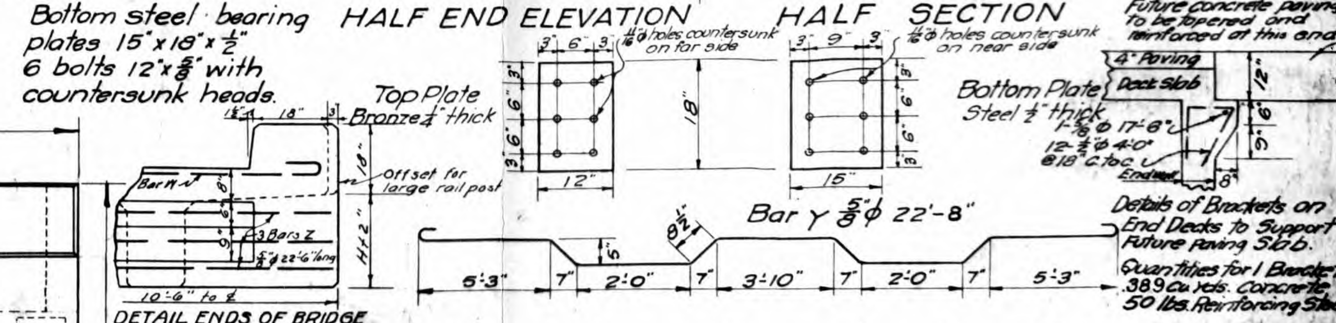
Designed C.H.C. Traced C.H.C. Submitted [illegible]

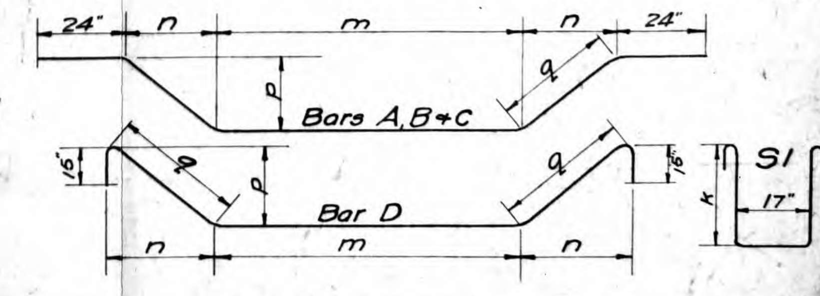
No. 350











DIMENSIONS FOR BENDING BARS

Length of Deck	Bar A n	Bar A m	Bar A p	Bar A q	Bar B n	Bar B m	Bar B p	Bar B q	Bar C n	Bar C m	Bar C p	Bar C q	Bar D n	Bar D m	Bar D p	Bar D q	Stirrup Length	S1 K	S2 K
40'	3'-8"	13'-10"	2'-9"	4'-7"	4'-0"	20'-0"	3'-0"	5'-0"	3'-8"	25'-10"	2'-9"	4'-7"	3'-8"	32'-4"	2'-9"	4'-7"	8'-10"	3'-2"	3'-3 1/2"
44'	4'-0"	16'-0"	3'-0"	5'-0"	4'-4"	22'-2"	3'-3"	5'-5"	4'-0"	28'-0"	3'-0"	5'-0"	4'-0"	35'-6"	3'-0"	5'-0"	9'-4"	3'-8"	3'-6 1/2"
48'	4'-8"	17'-4"	3'-6"	5'-10"	5'-0"	24'-6"	3'-9"	6'-3"	4'-8"	31'-4"	3'-6"	5'-10"	4'-8"	37'-10"	3'-6"	5'-10"	10'-4"	3'-11"	4'-0 1/2"
52'	5'-4"	19'-8"	4'-0"	6'-8"	5'-8"	25'-10"	4'-3"	7'-1"	5'-4"	33'-8"	4'-0"	6'-8"	5'-4"	40'-2"	4'-0"	6'-8"	11'-4"	4'-6"	4'-6 1/2"

GENERAL NOTES AND DESIGN DATA

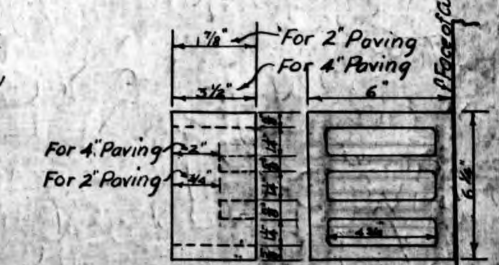
Specifications............Ga. Standard for Bridges.
Concentrated Load..........Typical 15 ton trucks.
Impact..........30% of live load.
Paving..........not to exceed 50 lbs. per sq. ft.

MATERIALS

Concrete..........Class "A" 1:6 mixture.
Aggregate..........Max. diameter 1 1/2 inches.
Reinforcing..........Steel bars.

Chamfer all exposed edges 3/4" unless noted.
For detail of railing, see Ga. Standard.
Expansion joints of asphalt and felt, formed thus

Finishes:- Top, inside and outside of curbs and brackets, rubbed.
Other parts, spade finish.
True up surface of slab with template and float.



CAST IRON INLET

DIMENSIONS

Total Length Feet	Depth H	Bar A	Bar B	Bar C	Bar D	Bar E	Stirrups S1	Bar W	Bar X	Bar Y	Bar V 28 Req'd.	Bar Z	Volume Concrete Cu. Yds.	Total Steel Pounds
40'	2'-9"	3-1 1/8"□ 27'-0"	3-1 1/8"□ 34'-0"	6-1 1/8"□ 39'-0"	6-1 1/4"□ 44'-0"	12-1 1/8"□ 44'-0"	78-5/8"φ 8'-10"	30	30	30	1/2"φ 21'	6	49.44	8675
44'	3'-0"	3-1 1/8"□ 30'-0"	3-1 1/4"□ 37'-0"	6-1 1/8"□ 42'-0"	6-1 1/8"□ 48'-0"	12-1 1/4"□ 48'-0"	84-5/8"φ 9'-4"	33	33	33	1/2"φ 23'	6	56.[illegible]	9927
48'	3'-6"	3-1 1/8"□ 33'-0"	3-1 1/4"□ 41'-0"	6-1 1/8"□ 47'-0"	6-1 1/4"□ 52'-0"	12-1 1/4"□ 52'-0"	93-5/8"φ 10'-4"	36	36	36	1/2"φ 26'	6	66.0[illegible]	11263
52'	4'-0"	3-1 1/4"□ 37'-0"	3-1 1/4"□ 44'-6"	6-1 1/4"□ 51'-0"	6-1 1/4"□ 56'-0"	12-1 1/4"□ 56'-0"	102-5/8"φ 11'-4"	39	39	39	[illegible]	6	76.83	12718

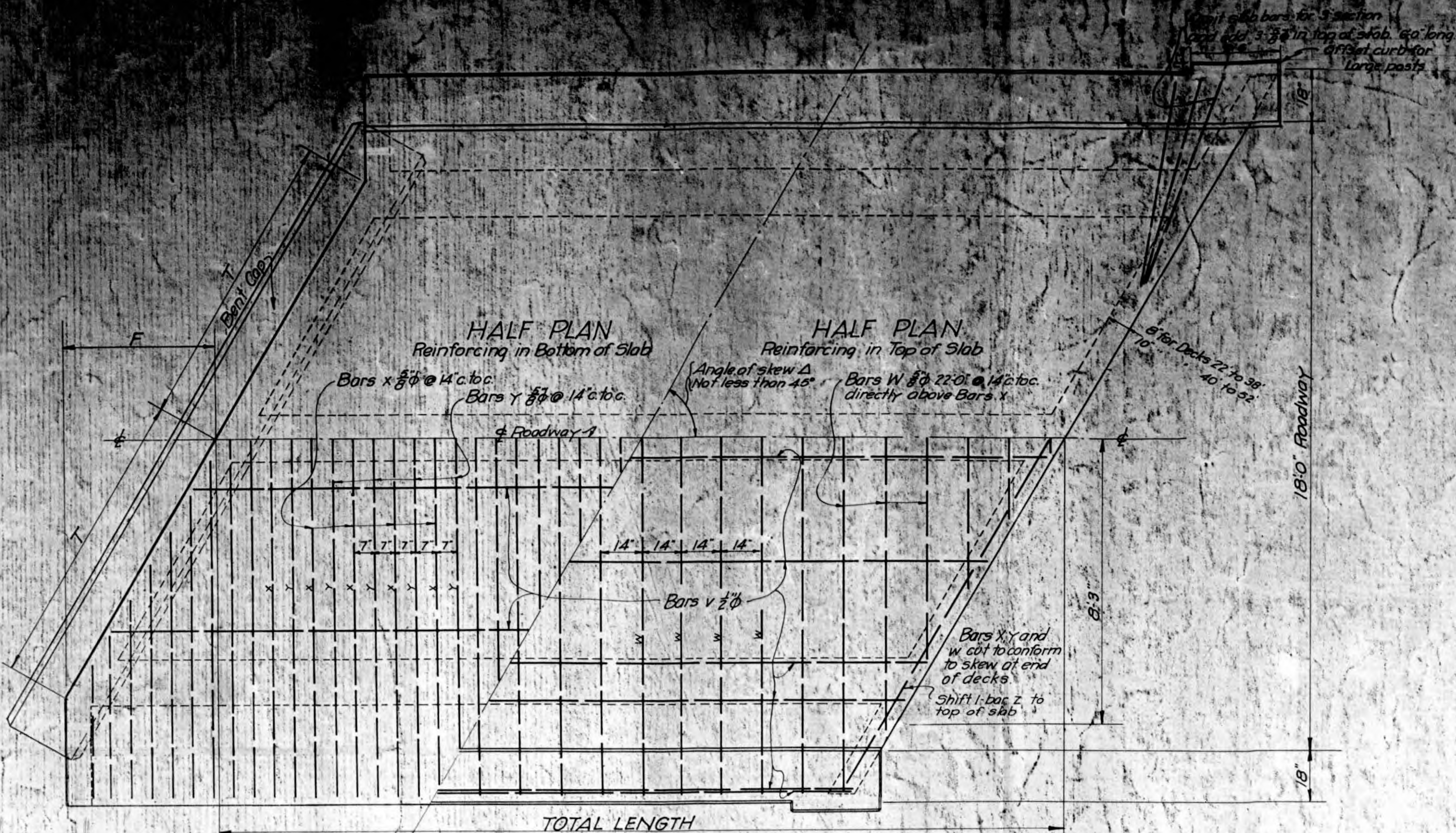
NOTE:- For each span 3 bronze plates 12"x18"x1/2" and 3 steel plates 15"x18"x1/2" and [illegible] 5/8"x12" bolts with countersunk heads required. Cost to be included in price of concrete. [illegible] and drain pipes will be paid for [illegible] price bid [illegible] reinforcement.

OLD No. 40

HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DEPARTMENT - ATLANTA

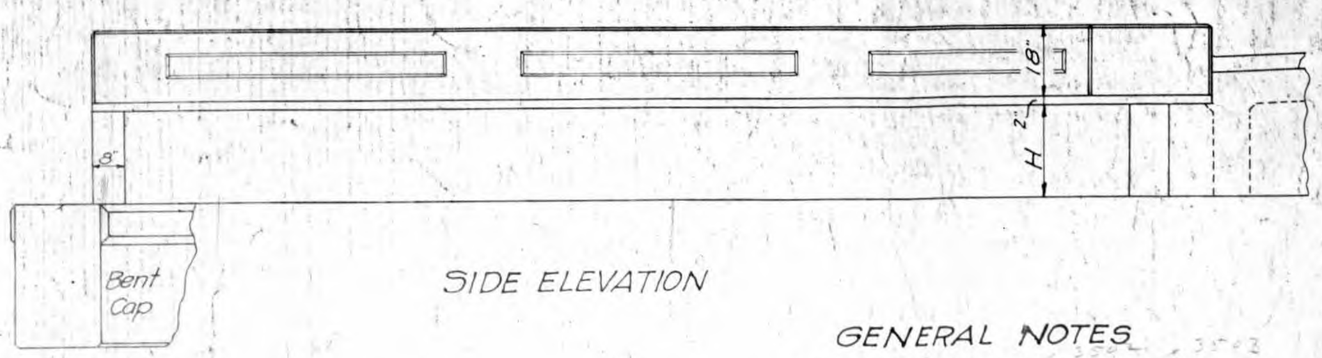
CONCRETE BRIDGE DECKS
LENGTHS 40'-0" TO 52'-0"
18'-0" ROADWAY

Feb. 19[illegible]



DETAIL AT INTERMEDIATE JOINT

DETAIL AT END OF BRIDGE



SIDE ELEVATION

DIMENSIONS AND TOTAL QUANTITIES FOR SKEW DECKS																						
Angle of Skew Δ	T	F	22' Deck		24' Deck		25' Deck		26' Deck		30' Deck		34' Deck		38' Deck		40' Deck		44' Deck		48' Deck		52' Deck	
	Ft. In.	Ft. In.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.
45°	10-7	7-6	21.41	3604	23.78	4141	24.69	4342	26.24	4658	30.75	6002	36.17	6770	45.48	8460	50.31	8707	57.04	9959	67.15	11295	78.10	12751
50°	9-9½	6-3½	21.31	3598	23.68	4135	24.59	4335	26.14	4652	30.64	5996	36.04	6764	46.34	8454	50.13	8701	56.84	9985	66.92	11289	77.83	12745
55°	9-2	5-3	21.21	3590	23.56	4127	24.47	4327	26.02	4644	30.51	5988	35.90	6756	45.18	8446	49.92	8693	56.61	9977	66.65	11281	77.53	12737
60°	8-9	4-4½	21.13	3585	23.48	4122	24.39	4322	25.94	4639	30.43	5983	35.80	6751	45.08	8441	49.78	8688	56.46	9972	66.47	11276	77.32	12732
65°	8-4½	3-6½	21.07	3580	23.41	4117	24.32	4317	25.87	4634	30.35	5978	35.71	6746	44.98	8436	49.65	8683	56.32	9967	66.31	11271	77.14	12727
70°	8-2	2-9½	21.03	3577	23.37	4114	24.28	4314	25.83	4631	30.31	5975	35.67	6743	44.93	8433	49.58	8680	56.24	9964	66.22	11268	77.04	12724
75°	7-11	2-0½	20.99	3572	23.32	4110	24.23	4310	25.78	4626	30.26	5970	35.61	6738	44.86	8428	49.50	8675	56.15	9960	66.11	11263	76.91	12720
80°	7-10	1-4	20.97	3572	23.31	4109	24.22	4309	25.77	4626	30.24	5970	35.59	6738	44.84	8428	49.47	8675	56.12	9960	66.08	11263	76.87	12720

GENERAL NOTES

This standard to be used in connection with Ga. Standards 3502 and 3503 showing decks on skews of 45° to 80°.

All details not shown are the same as on Ga. Standards 3502 and 3503

Specifications:- Ga. Std. for Bridges.

OLD No. 68-S

STATE HIGHWAY DEPT. OF GEORGIA
BRIDGE DEPARTMENT

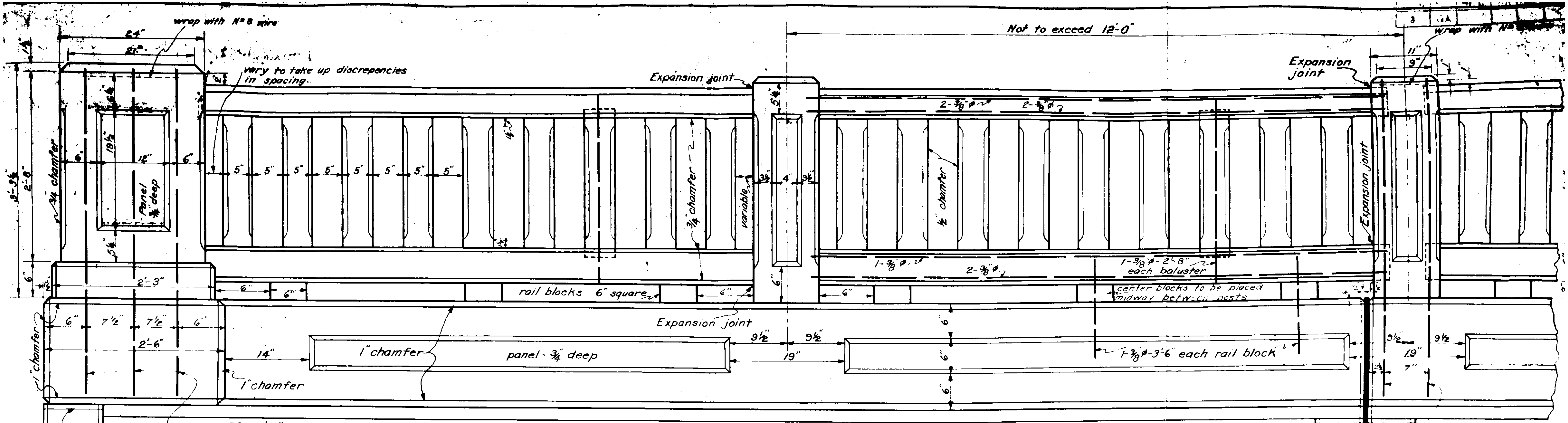
ESKEW CONCRETE BRIDGE DECKS
LENGTHS 22' TO 52' 18' ROADWAY
TO BE USED WITH STDS. 3502 AND 3503

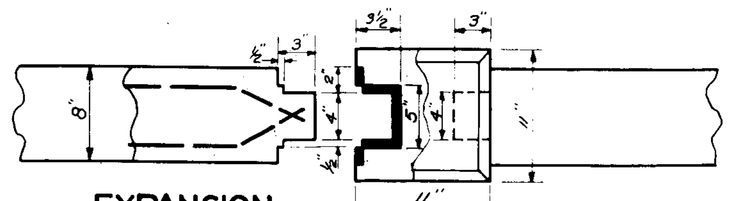
NO SCALE OCTOBER 1924

Designed C.N.C.
Traced C.N.C.
Checked
Revised 11-28-28

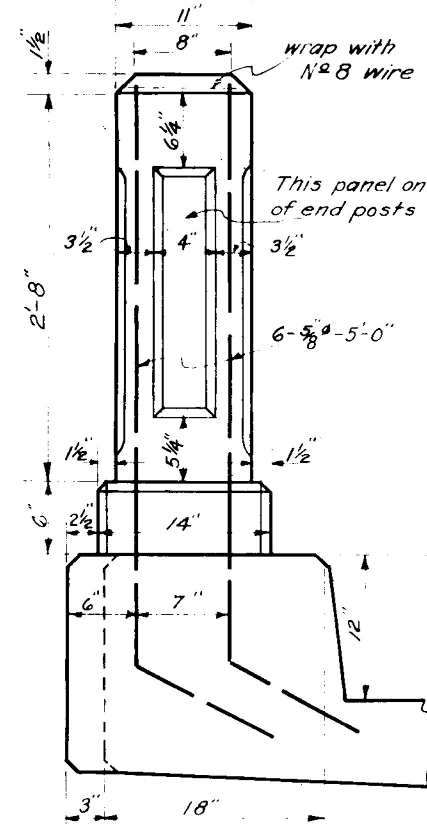
Submitted Searcy B. Slack
Bridge Engineer
Approved
State Highway Engineer

NO. 3504

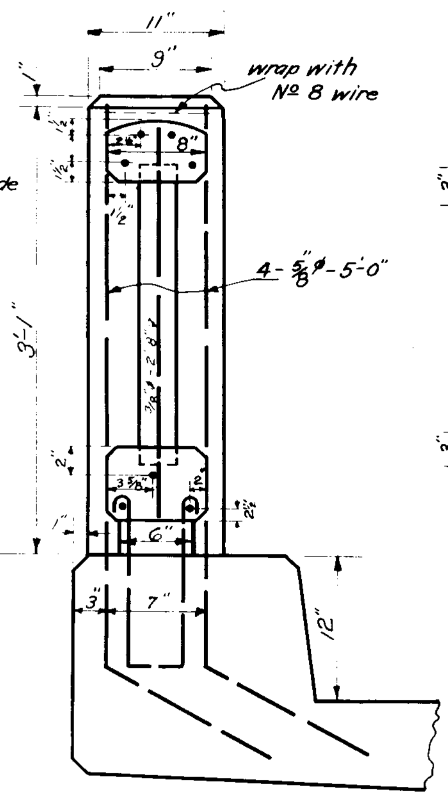




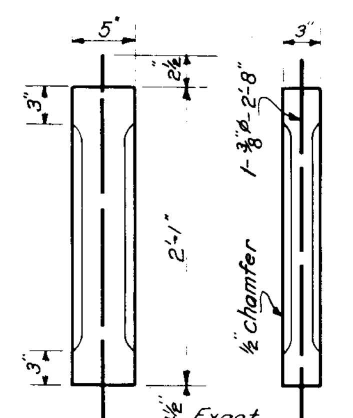
EXPANSION JOINT



LARGE POST



SMALL POST



BALLUSTER

GENERAL NOTES

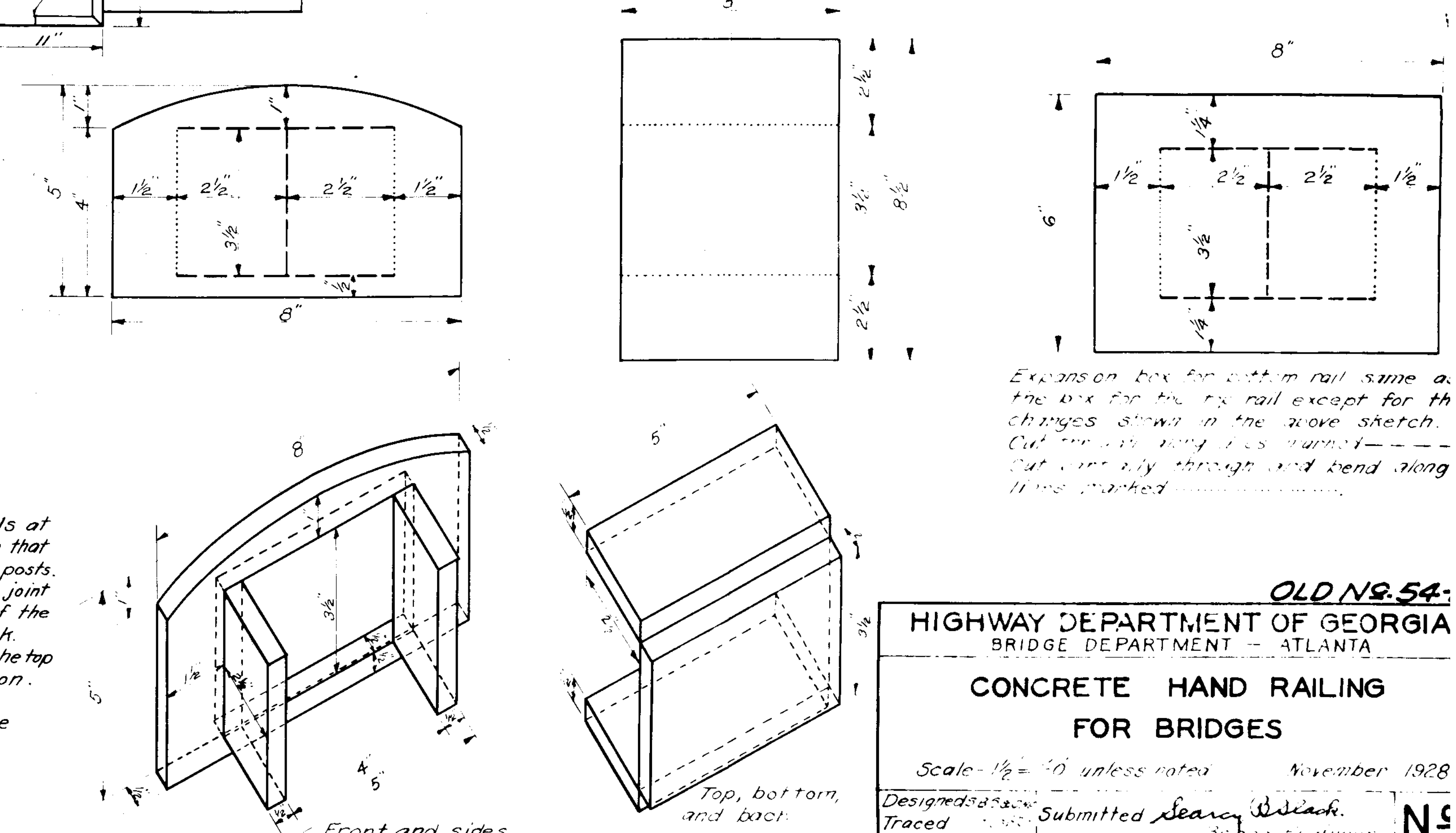
Expansion joints shall be provided in rails at one end of each section; a section being that part of the rail included between two posts. At the end of each deck, the expansion joint in the rail shall be on the same side of the post as the expansion joint in the deck. Expansion joints shall be provided in the top and bottom rails at the same section.

All timber used in rail forms shall be dressed, and at least 2 inches thick.

Concrete to be of 1:5 mix - Class D.
Maximum size aggregate = ¾.
Reinforcing of steel bars.
All surfaces to have rubbed finish.

QUANTITIES

END POST		INT. POST		PER LIN. FT. BETWEEN POSTS	
Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.	Conc. Cu. Yds.	Steel Lbs.
.235	31	.097	21	.031	4



Expansion box for bottom rail same as the box for the top rail except for the changes shown in the above sketch. Cut the box along lines marked — — — Cut part way through and bend along lines marked ....

EXPANSION BOX FOR TOP RAIL
scale ½" = 1"

OLD Nº 54-

HIGHWAY DEPARTMENT OF GEORGIA
BRIDGE DEPARTMENT - ATLANTA

CONCRETE HAND RAILING FOR BRIDGES

Scale - ½" = 1'-0" unless noted — November 1928

Designed	Submitted Searcy B. Slack
Traced	Bridge Engineer
Checked R.H.J.	
Revised	Approved [signature]

Nº 360

C O N S T R U C T I O N

Construction of the bridge was started May 9 ,1927.

Two or three days prior to this time, the river was triangulated, and the bents out of the water on either side of the river were staked out. The piers in the river could have been located and staked out at the same time by using boats and a system of triangulation; but it was not deemed necessary, inasmuch as Mr. J. D. Gates, Superintendent for the Contractor, had already expressed his intention of driving false work piles across the river at an early date. This, of course, would facilitate the location of the piers and would eliminate the possibility of making errors in triangulation computations.

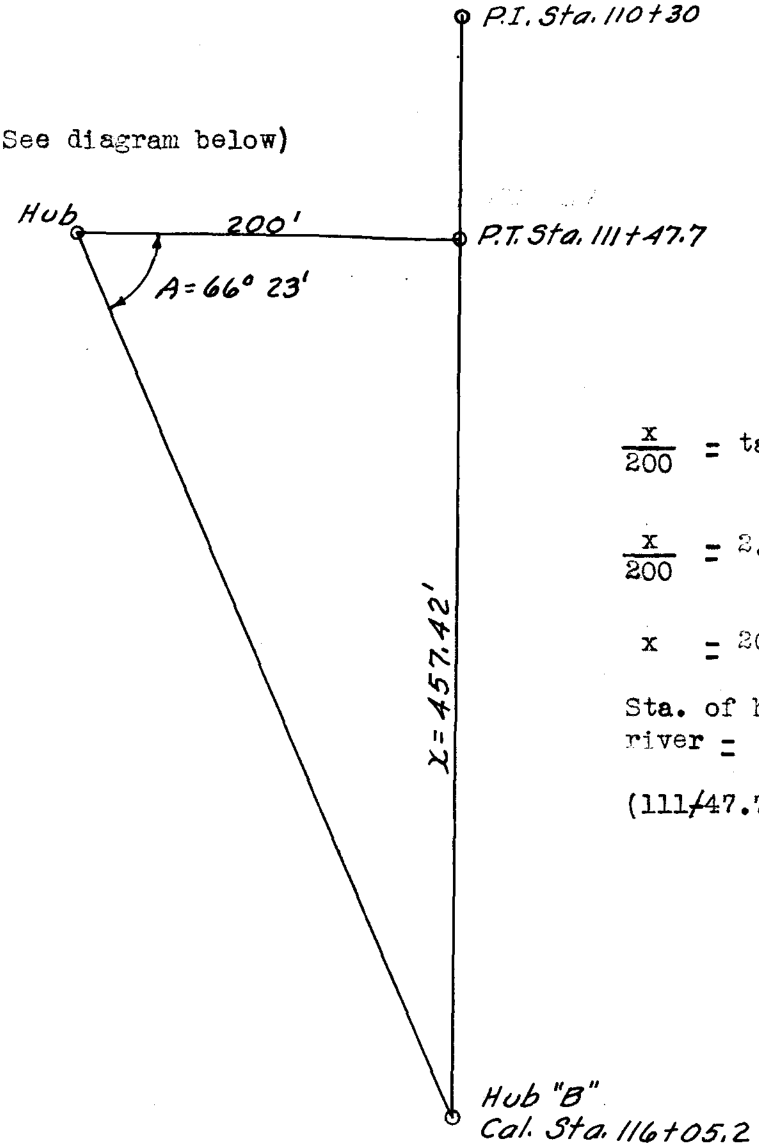
The matter of triangulating the river was a rather simple procedure.

A P.I. stake at sta. 110+30 and a P.T. stake at sta. 111+47.7 on the west side of the river, which were established when the survey was made by the locating party, were found. The transit was set up over a tack in the P.I. stake, sight taken on a tack in the P.T. stake, and a tack point established in a hub conveniently located on the opposite side of the river.

Next, the transit was set up over the tack in the P.T.stake, sight taken on the tack in P.I. stake, checked by plunging the telescope and sighting on the tack in the new hub on the opposite side of river, then turning an angle of 90° down the river. On this line,200 ft. down stream, another tack in a hub was established.

The transit was then moved down to this point, set up over the tack, sight taken on the tack in P.T.stake, the angle A turned to the tack in hub on opposite side of river and read.

(See diagram below)



$$\frac{x}{200} = \tan 66^\circ 23'$$

$$\frac{x}{200} = 2.2871$$

$$x = 200 \times 2.2871 = 457.42 \text{ ft.}$$

Sta. of hub on opposite side of river =

(111+47.7)+(4+57.42)= 116+05.12

After determining the station number of hub B, it was a simple matter to locate the bents on the East side of river, the station numbers of which had been previously calculated.

The method used in staking out the bents and piers not in the river was this - a stake was driven at the previously calculated bent stations on the center line with a tack in each. The transit was then set up successively over the tacks in each of these stakes, and with a back sight on some convenient tack in a hub, preferably on the opposite side of the river as a short back sight multiplies any slight discrepancy in trying to sight exactly on the center of the tack, a 90° angle or a 60° angle, as the bent required, was turned off the center line of bridge. On this line, about 25 ft. to each side the center line in most cases, although any reasonable distance could have been used so long as it was sufficiently far away so as not to be covered up by excavated material or disturbed by work on the footings, a hub was driven and a tack set exactly in line and at the exact chosen distance from the center line tack over which the transit was set up.

By stretching a line between the tacks on either side of the center line, the center of the bent could be made available at any time for setting footing or other forms; and by knowing the exact distance from these tacks to the center line, the forms could be set, and lined correctly in both directions. The center line stakes are always knocked entirely up or badly out of line during the process of excavating for the footings, or they could be used to measure from; then the offset hubs could be set at random on either side of the center line and used only for locating the transverse center of bent.

The same procedure as above was followed in staking out the river piers, except that transit set ups had to be made on the falsework and all tacks set in falsework. This necessitated the checking of these tack points at frequent intervals, inasmuch as the false work was not very rigid, and the constant shifting of the pile driver and driving of piles shook these points slightly out of line. However, the changes were very small and much less than anticipated.

As the bents were staked out, elevations were taken on the ground at the approximate corners of the footings, if the ground was very irregular, or only at the center of footings if the ground was fairly level. These elevations of course were taken with respect to a Bench Mark near the river established by the locating party, and from which the elevations of finished grade on bridge and etc., were calculated. From the elevations of original ground and the elevations of the bottoms of footings as finally accepted before they were poured, the amount of excavation was computed.

As per the specifications, excavation is allowed and calculated for a hole one foot larger in each direction than the actual size of footing. This is to allow the contractor room for his sheeting, bracing, and forms.

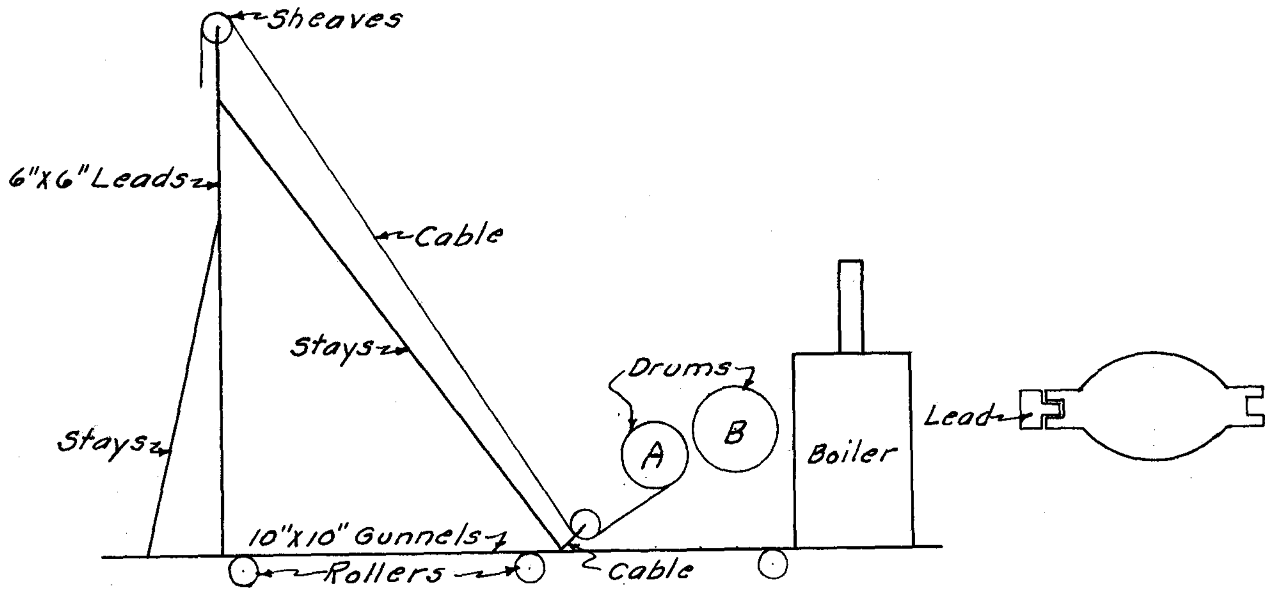
The contractor was ready to begin work just as soon as the bents were staked out, and he chose to begin with bent No. 14 on the East side of the river.

A crew of laborers was put to work excavating for the three footings of this bent. The bottoms of the footings were only a few feet below the surface of the ground, and the character of the clay in which they were excavating was such that it was hard enough to stand alone without it being necessary to sheet the holes.

While one foreman had his crew of laborers excavating, another foreman who was to have charge of the pile driving was erecting his pile driver. The boiler and engine, with the necessary cable, sheaves, and etc., had already been shipped in and unloaded near the location of bent 14, where work was to begin.

The first pile driver erected was of a rather simple type, for it was thought at that time that foundation piles were only going to be driven for the two end bents.

A sketch of the driver is shown below:



The leads were cut with projections to fit into the grooves at the sides of the hammer as shown and thus it was guided and held in place as it was pulled up or as it fell. The cable from drum A operated the hammer, while the cable from drum B was used to pull the driver forward or sideways as required.

Excavation for bent 14 was soon completed, whereupon the pile driver was skidded into position on heavy timbers placed across the holes, and the piles driven. The specifications require a foundation pile to have a minimum bearing of 15 tons as determined by the

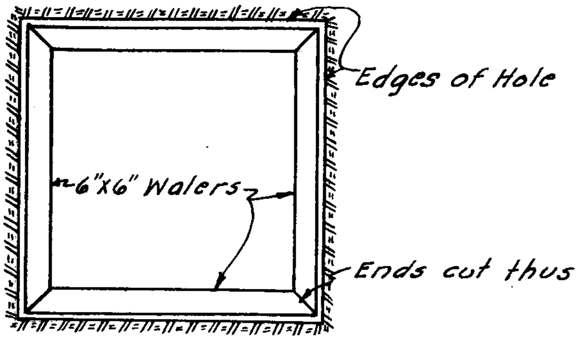
Engineering-News formula; viz., $p = \frac{2WH}{S + 1.0}$, where p equals the safe bearing power in pounds, W equals the weight of hammer (2,000 lbs. minimum allowable for gravity hammers on timber piles), H equals the height of drop of hammer in feet, and S equals the average penetration for the last five blows.

A typical table with all data for every pile driven for bent 14 is included at the end of this section.

No difficulty was encountered in driving these piles, and as soon as the "cut off" elevations were given, they were sawed off and forms for the footings were set from the hubs already established as previously explained. The concrete was then poured into the forms, the ends of the 1" square column bars were stuck into the concrete and braced in place.

In the meantime the pile driving crew had been driving false work piles for deck 13-14. These were driven almost to the ground, sawed off level, and left until needed. Later, other piles on which the deck form work was to rest, were rested on top of these and braced in place.

As soon as the footings for bent 14 were poured, excavation was started for bent 13 footings. By referring to the "Plan and Elevation" sheet of the bridge plans, it may be seen that rock was shown 15 or 16 feet below ground, and for a hole that deep, sheeting was necessary. Excavation for these footings, as well as for the remaining footings out of the water, all of which required sheeting, was conducted in the following manner - First, holes one foot larger in each direction than the footings were dug at the proper locations, two or three feet deep. Next, 6"x6" walers cut as shown below were placed in the bottom of the holes.



2"x8" wood sheeting 15 feet long was used for the footings out of water, and this was stood up around the walers next to the sides of the holes. Scaffolding was then built around the sheeting at sufficient height to permit men standing on it to drive the sheeting with heavy wooden mauls.

Men inside the sheeting picked and shovelled the dirt out, always keeping the walers driven down to the bottom of the hole, while the men on the scaffold drove the sheeting down.

At intervals of about three feet, as the sheeting was driven down, additional walers were added. This is necessary to keep the sheeting in line. To keep the walers spaced uniformly, 6"x6" timbers were cut 3 ft. long and one stood on end at each corner between the walers. Then by driving on the corners of the top walers, all walers below were kept pushed down.

As the depth of the holes increased, platforms inside the sheeting were built, and the dirt was thrown up to a platform, and from there out of the holes; or onto another platform, then outside, if the depth of the hole required it.

This was the method used for excavating, as previously stated, for bents 1, 2, 10, 11, 12, and 13, and piers 3, 8, and 9.

But to get back to bent 13. After a depth of 3 or 4 feet had been reached, the holes began filling up with water, and it was necessary to start the pumps. At first, two diaphram hand pumps kept the water down; but soon the water began to rise so rapidly, it was necessary to use a 6" centrifugal pump, with a 4 cylinder engine to pull it.

In the meantime, gravel had been encountered and it was getting coarser as the depth of the holes increased. Large boulders were getting rather frequent, and this made it extremely difficult to drive the sheeting. Occasionally, a large boulder had to be dug from beneath a piece of the sheeting before it could be driven any deeper.

We were just considering pouring the footings on these boulders for a foundation, and an elevation was taken in the bottom of the holes from which to calculate the excavation, when the water started gaining on the pumps, and with all available pumps at work, we were not able to lower it.

The only recourse left was to seal the footings by means of a tremie. The pumps were stopped and the holes were permitted to fill with water.

An improvised tremie was quickly made out of 2"x8" planks with a funnel shaped mouth and a false bottom.

The operation of the tremie was as follows: First, by means of a gin pole and pulleys, the tremie was held high enough for the lower end to be clear of the water. Then it was filled to the top with concrete, and slowly lowered into the water until it rested on the bottom of the hole. The false bottom was next loosened and by slightly raising the tremie some of the concrete ran out. Additional concrete was dumped into the mouth of the tremie, and again it was slightly raised. Extreme care had to be exercised in raising the tremie, or all of the concrete would run out, and the entire procedure of pulling it out of the water, recharging it, and lowering it to the bottom again would be necessary.

After we had poured what we deemed a sufficient seal course in each hole the tremie was removed, and the concrete was permitted to set 24 hours before any more pumping was done in the holes.

Although the plans specified class "B" concrete for the footings, the specifications require all concrete poured through a tremie to be class "A" with 10% additional cement.

Next day the holes were pumped out, the surface of the seal course cleaned off, forms for the remaining height of the footings set, and the footings poured.

On the original tracing of the "Plan and Elevation" sheet, the depths of the footings as constructed are shown in red. However, the red figures photostat the same as the other figures, but they may be recognized by virtue of the fact that they are either shown to hundredths of a foot, or are the figures farthest from the footing dimension lines shown on the elevation of bridge.

Gravel and boulders were encountered in all the holes excavated for piers 8 and 9, and bents 10, 11, and 12. Steel rods were driven in each of the holes several feet deeper after a sufficiently good boulder foundation had been reached, to determine if solid rock was any where near; but it was never reached. Consequently, all these footings were poured on boulder foundations, with the exception of pier 8. Due to it's proximity to the river, there was some danger of scour, and foundation piles were driven under it.

No serious "blow ins" occurred while excavating for these footings, so it wasn't necessary to seal any of them with the tremie.

By this time the pile driving crew, in addition to driving foundation piles for pier 8 and bent 14, had driven all the necessary false work piles for the decks on the East side of the river.

Four lines of four piles each, one line about 3 feet from each bent, the other two lines being equally spaced, were driven for the 34 ft. decks; and 5 lines of 4 piles each were driven for the 52 ft. decks.

At this juncture in the construction, it was agreed that very likely no rock foundation was going to be found and that it would be necessary to drive piles for the remaining piers and bents. In view of the fact that foundation piles for the river piers, if found necessary, would have to be driven from falsework above the river, and also due to the fact that heavy steel sheet piling was going to be used for the river footings, the superintendent in charge decided to dismantle his pile driver and rebuild it with a swinging boom and swinging leads to facilitate the driving of these piles and the handling of the steel sheet piling.

Plate 3 is a picture of the rebuilt pile driver.

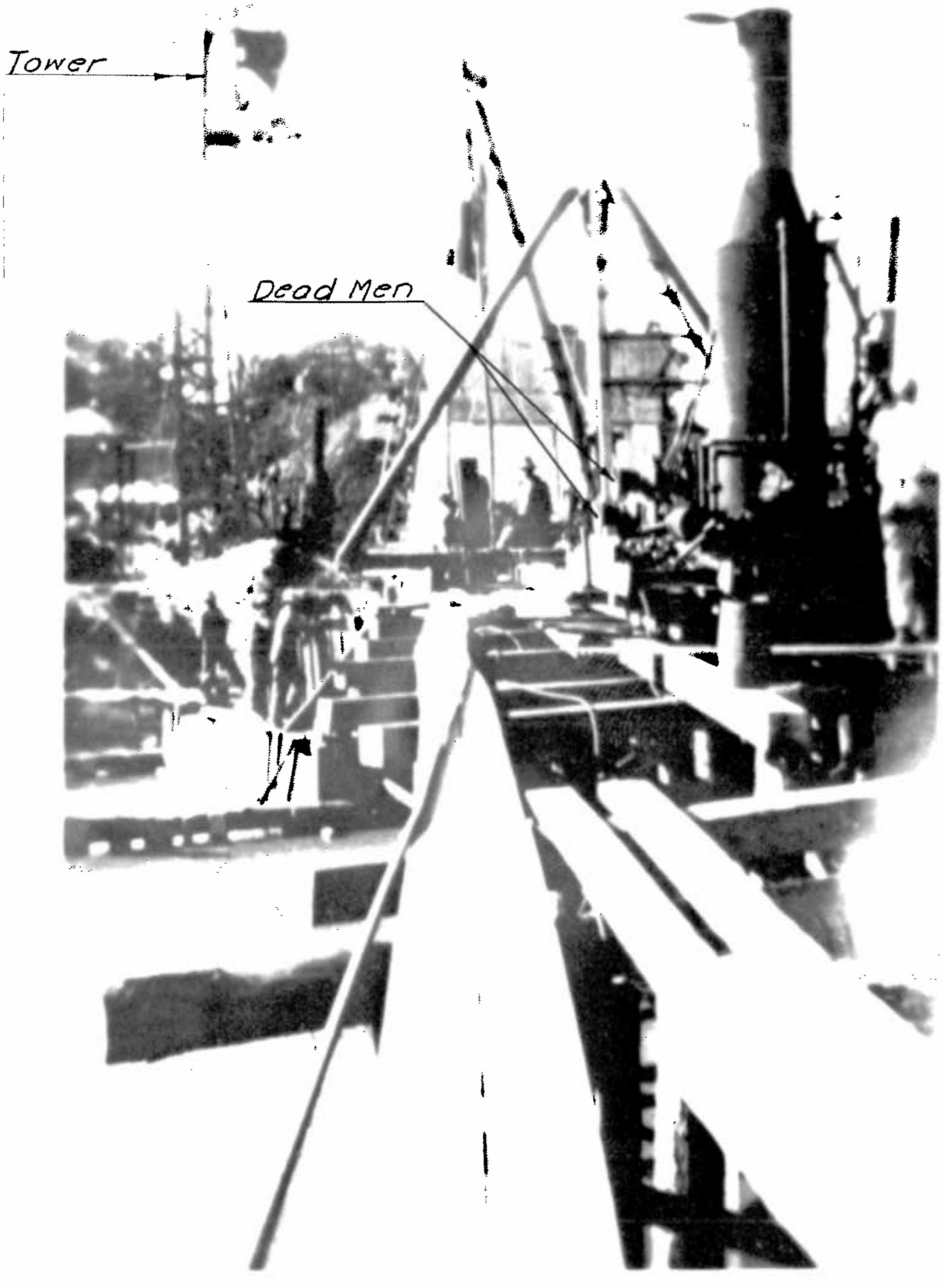


Plate 3

The boom was attached near the bottom of the center post (almost hidden in the picture by one of the stays) which had a swivel joint at top and bottom. The cable from one drum of the hoist was used to raise or lower the leads, while the other was used in operating the hammer. The boom was swung from side to side by means of ropes and pulleys and the "dead men" (See **Plate 3.)**

As soon as the pile driver was completed all remaining false work piles were driven. Those in the river were driven in this manner - first, four piles were driven where a false work bent was desired, a 10"x10"x21' timber cap placed on them and a dowel pin driven through the cap into each pile. The pile driver was then skidded on 10"x10" timbers up to the bent just driven, and by means of the long boom, another pile bent driven several feet forward and capped as before; and etc. until all had been driven.

From plate 3, you also get a good view of the pile driver resting on the river false work bents.

Excavation for the river pier footings proceeded in much the same way as previously explained for the footings out of water, except for the fact that instead of sheeting a separate hole for each footing, a hole large enough to accommodate both footings was sheeted. This was the most economical for these footings, for there was very little space between the footings after they were enlarged to take piles and the amount of extra excavation was negligible, when compared with the extra cofferdam work which would have been required for two holes.

First 8"x8" walers were cut the required lengths, nailed together, and placed on falsework at the correct location for the footings. The leads and hammer were removed from the pile driver, and a large hook fastened to the end of one of the cables. This was for handling the 12"x24" steel sheet piling, which it was necessary to use for the river footings.

Next by means of the hook just mentioned, the steel sheet piling was stood up around the walers, each piece being interlocked to the adjacent piece by a patented tongue and groove joint. As soon as all the piling was placed, a steam hammer was attached to the cable in lieu of the hook and each piece of piling driven two or three feet to get it firmly set.

A picture of the steam hammer attached to the cable may be seen on plate 4, although it is inverted in this picture, and is being used to pull the piling.

After all the steel sheet piling had been firmly set, work on the cofferdam was started. Wood sheeting was driven around the steel sheeting about 5 ft. from it, and the intervening space filled with clay.

When this was completed the hole was pumped out, the original walers driven to the ground, and another set placed. The steam hammer was then again placed on the steel sheeting and it was driven to within two or three feet of water elevation.

Due to the size of the enclosure it was possible to excavate with a clam shell bucket, so the steam hammer was removed from the cable and a clam shell substituted, which materially expedited the progress of excavating.

Additional walers were added as the depth of hole required. The length of the enclosure was such that intermediate struts between the walers were ncessary.

The gravel in the river bed was so porous that it was necessary to procure additional pumping facilities to handle the water in the

Plate 4

cofferdams. A 6" Emerson steam pump was shipped in; then an 80 H.P. boiler had to be rented and moved out to the bridge site to operate the pump. This pump in addition to the 6" centrifugal pump already on hand solved the pumping problem, however, for the remainder of the work. After the excavation was completed, the steam hammer was removed, and the leads and gravity pile hammer were again attached to the cables of the driver. Piles were driven to the required bearing capacity, then cut off at an elevation which allowed them to project one foot up into the concrete. All material loosened by the driving of piles was shovelled out of the hole; forms built, and the concrete poured. One inch square dowel bars were set in the concrete, to which later the pier column bars were attached.

All the footings on the East side of the river were poured with a one bag mixer, while those in the river and on the West side were poured with a two bag mixer.

The one bag mixer was light and could be rolled up near the footing to be poured; the concrete being transported from mixer to footing by means of wheelbarrows.

The two bag mixer, however, was a heavy steam mixer, and was permanently located at the West end of the bridge. A sixty foot tower which may be seen on plate 3, was erected adjacent to the mixer, so that the concrete, when mixed, could be dumped directly into a container in the tower, and raised by means of a gasoline hoist to the top of the tower. Here the container automatically tripped, and the concrete poured into a chute. The chute was moved from footing to footing, if they were not too far distant from the tower and the concrete run directly into them. When the footings were too far away to get enough grade on the chute for the concrete to flow, it was "chuted" as far as possible, caught in a large hopper resting on falsework, then transported by wheelbarrows or concrete buggies to the point where needed.

The chute was in sections, so could be lengthened or shortened as needed. It was suspended from a cable running from the top of the tower and anchored on the opposite side of the river.

A picture of the hopper used may be seen on plate 5, although in this picture it is sitting on one of the decks that has been poured. Note the chute leading into it.

The concrete in the footings was given sufficient time to set, then the steel sheet piling was pulled and placed ready to use for the next footing.

The piling was "pulled" with the steam hammer as mentioned previously, and may be seen in action by referring to plate 4.

The steam hammer was suspended by the cable from the pile driver in an inverted position; the hammer driving upward against a steel strap which was attached to the steel piling. The diagram on next page will give an idea of the operation -

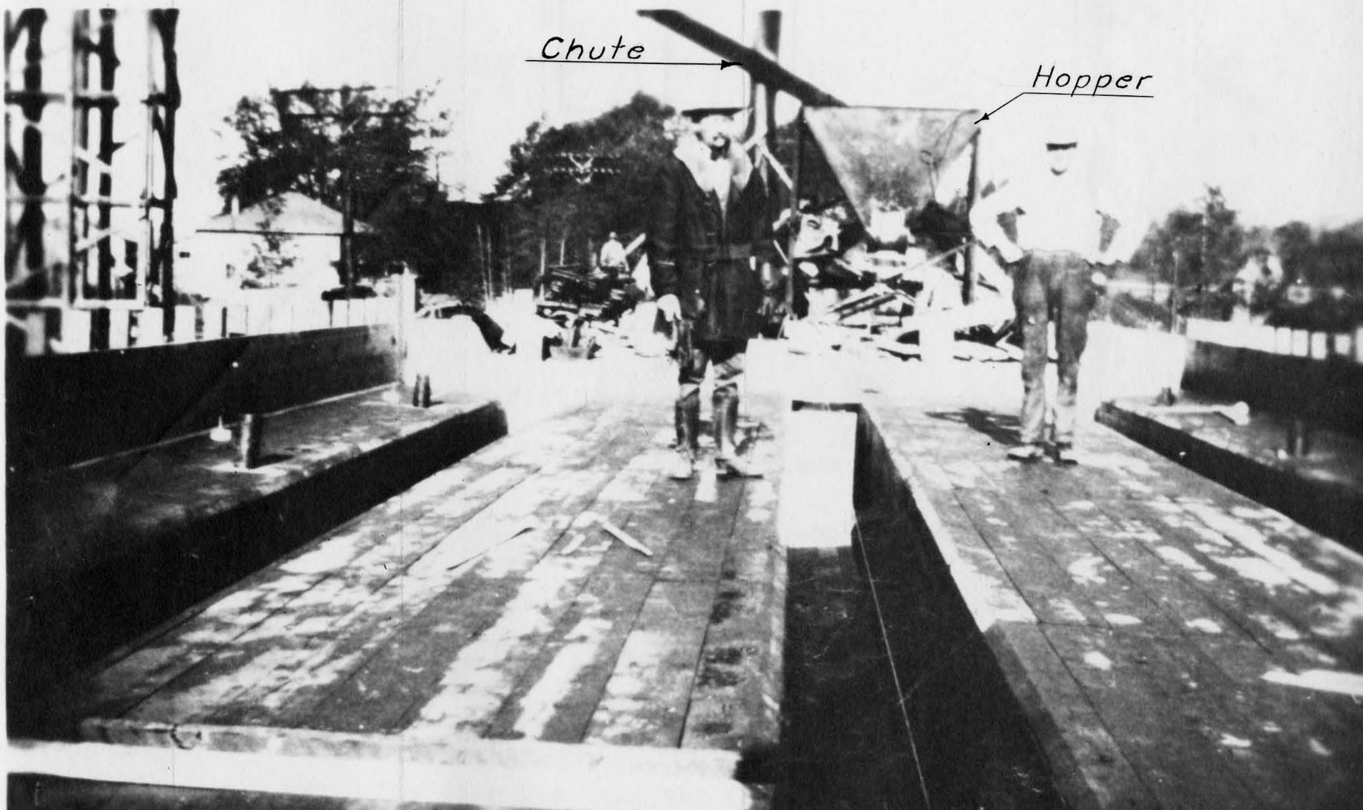
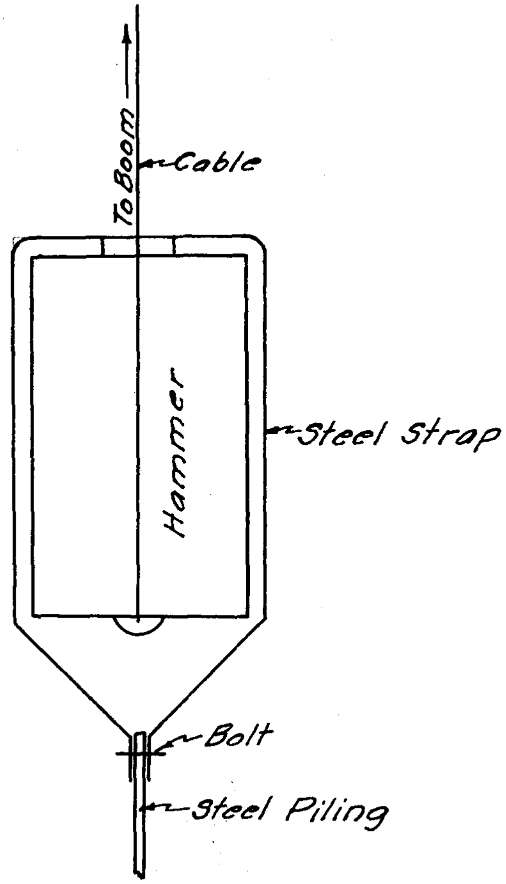


Plate 5



After all the footings were poured, the reinforcing steel for pier and bent columns, and pier walls was placed, the forms set, and the concrete poured. All form lumber used was two inches thick.

Plate 6 shows the forms on a pier that has been poured; as well as the deck forms for one of the dceks that rests on this pier.

Next, the pier and bent cap forms were set, the reinforcing steel placed and the concrete poured. Of course, a different set of forms was not used for each separate cap, but as soon as one cap had been poured and allowed to set for 48 hours the side and end forms were removed and used for the next cap.

The bottom forms had to stay in place for 21 days, as per specifications, for they supported the weight of the cap and could not be removed until the concrete had developed a 21 day strength. For

Plate 6

this reason, several sets of cap bottom forms had to be built.

While the bents and piers were being built, the carpenter crew had been busy making deck forms in sections ready to be moved in and placed as soon as the substructure caps were poured.

In the meantime, falsework bents were being erected to support the deck forms. On each side of the river where falsework piles were driven, then sawed off to within a few inches of the ground, as previously explained, other piles were merely set up on these and toe nailed to them. Then they were cross braced to hold them in place, and capped off at the top with a 10"x10"x24'0" cap, sufficient allowance being made for supporting timbers and form work so as to bring the bottom of the girder forms when placed approximately to the top of supporting bent or pier cap. By means of large oak wedges placed between the timber falsework bent caps and the longitudinal timbers on which the deck forms rested, the forms were eventually brought to the exact desired position.

These oak wedges also served to put camber in the deck forms before the concrete was poured, the explanation and purpose of which will be taken up under the pouring of the decks.

For the river false work, 5/8" Ø dowels were driven into the caps of the pile bents already driven and previously referred to on plate 3, then holes to accommodate these dowels bored in other piles which were subsequently set up on them, braced in place, and capped off at the top as explained for the other falsework pile bents. Thus, the river falsework bents were what are referred to as double deck bents - that is they require two caps in their construction with sections of piles between them.

The false work and form work for all decks were practically the same, so a typical deck will be discussed here.

On top of the falsework bent caps were placed five lines of 12"x12" timbers parallel to the center line of the bridge, each timber being long enough to reach from one timber bent to the next timber bent and to lap past the next 12"x12" in line, so that all the 12"x12" timbers would have a full bearing on the bent caps. There was one line of these 8"x8"s under each of the three girders, and a line under each of the two curbs.

On top of the 12"x12" timbers and at right angles to them were placed 6"x6" timbers at about 2 feet center to center. These timbers are noted on plate 7, as well as the girder side form studs, and the runners that hold the girder side forms in line. In this picture, the girder side and bottom forms have been set, but the slab forms have not been set.

The deck forms are assembled in this order - First, a line is stretched from the center point, set by transit, of one pier or bent cap to the center point of the next pier or bent cap. The sections of the bottom form for the center girder are then brought in and placed under this line - the line being used as a guide marking the center line of the girder. As these girder bottoms were placed, they were nailed to the 6"x6"s just underneath, to hold them in place.

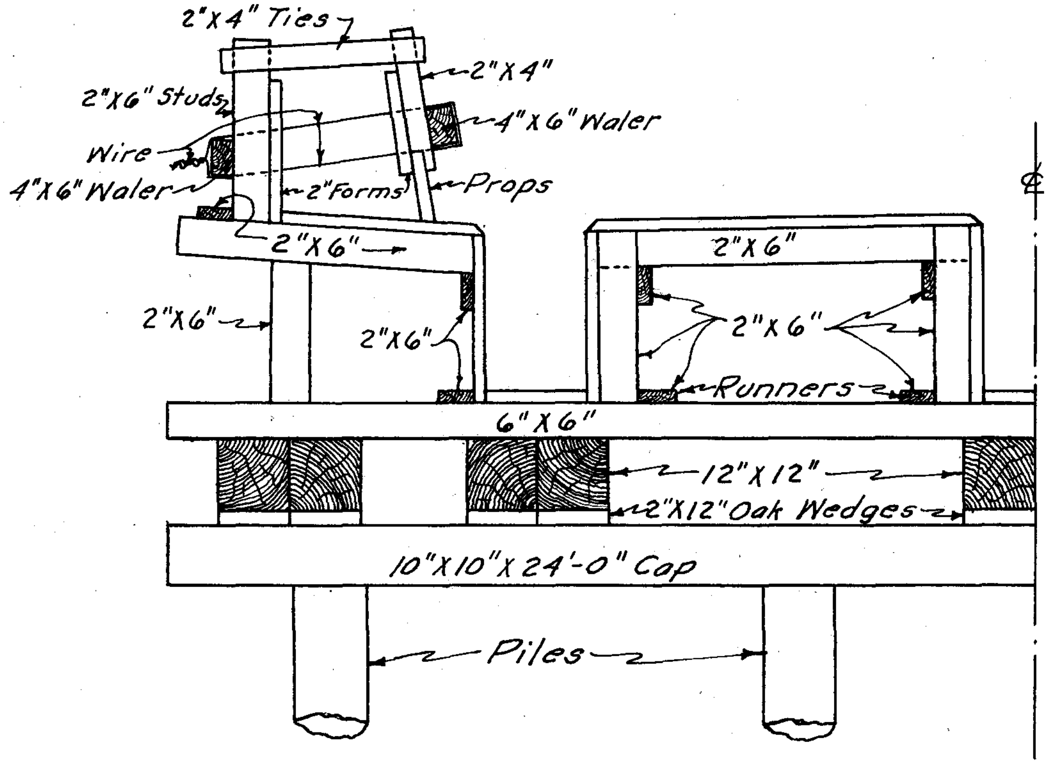

2"X6"
Knee Braces
Knee Braces
Girder Side Forms
Studs
2"X6" Runners
6X6's

Plate 7

Next, by direct measurement along the pier or bent caps the center of each of the outside girders was located, a line stretched, and the girder bottom forms set as before. As soon as all the girder bottoms were placed the girder side forms were brought in and set.

Plate 7 was made just after these side forms were set. Note the runners nailed to the transverse 6"x6"s that run under the girders. These hold the bottom of the side forms in place.

Now note the several knee braces shown. These were adjusted until the girder sides were vertical, then nailed in place to serve until the slab forms were placed. The slab forms, after being placed, held the girder sides in line, so the knee braces were of no further use. The sketch below will illustrate.



Immediately after the completion of the deck form the reinforcing steel was brought in and placed. The order followed in placing the reinforcing was this - first, stirrups in the girders, then longitudinal girder bars, then bars X, bars V, bars W, and last, bars Y.

The reason for this order may be easily understood by referring to the detail sheets of decks, Georgia Standards No. 3502 and No. 3503.

To obtain the correct cover for the slab and girder reinforcing, small cement mortar blocks, which had been poured quite a while previously for this purpose, were placed at intervals under the bars.

The transverse bars were then wired to the longitudinal bars at the required spacing. Next the rail post bars were placed in the curb forms, being held in position by templates nailed across the top of the curb forms.

Plate 5 shows a deck form complete with the exception of the inside curb forms. Note the drain pipes in place.

As previously mentioned, just before pouring a deck, a certain amount of camber had to be put in the forms to offset any settlement that might take place due to the joints in the falsework squeezing together and the timbers compressing as the load was applied. A general rule followed was to allow 1/8" for each joint in the falsework under the point in question, and the deck form was raised at each bent by means of wedges (see sketch, sheet 79), an amount equal to that computed.

The theoretically computed settlement did not always check with the actual settlement, in which cases the wedges were either slacked off or driven tighter as the case required.

A constant check was kept on the settlement of the form by means of strings stretched under the bottom of each girder and each curb. The strings were set a measured distance below the bottom of the form. The ends of the girder bottom forms were kept flush with the tops of the supporting caps by means of the wedges, so they were known to be right. Then by measuring from the strings up to the bottoms of the forms, the settlement taking place at any point could be determined.

Plate 8 shows a deck ready to be poured. All the reinforcing is in place with the exception of the small stirrups that project from the curb up into the concrete blocks under the bottom hand rail. These were mashed down into the curb just after the concrete had been poured. Note that benches to support runways for the concrete buggies have been placed.

Pouring will begin at the end of the deck farthest from the mixer and proceed toward the mixer. The order of pouring followed was this; end wall and 3 or 4 feet of girders first; slab then poured up to a point about in line with end of concrete in girders; another 3 or 4 feet of girders; another section of slab; and etc. until the deck is completed. This method of pouring gives the concrete in the girders time to settle before the slab concrete is poured, thus circumventing any cracking that might occur, where the girder and slab join, due to shrinkage of the girder concrete. Also, the time interval between the pouring of a section of girder and the slab immediately over it is not enough to cause a construction joint, which is not allowed.

Twenty four hours after a deck was poured, the inside and outside curb forms were removed, and the concrete rubbed with carborundum

Plate 8

bricks to secure a "rubbed" finish.

About 21 days after a deck was poured, the top surface of the slab was painted with an asphalt paint in preparation for the paving to be poured later. The paint was to prevent any bond between the paving and slab. The reason for this was that when it became too worn for further use, it could be broken up, removed, and replaced with new paving.

Most of the decks, although not all of them, were poured before any of the hand rail posts, or hand rail, were poured.

A form that would accommodate about twelve of the precast balusters for the hand rail was constructed several weeks before any of the hand rail was to be poured, and the pouring of these balusters was begun. They were permitted to set for 24 hours after being poured, then taken out, rubbed with a carborundum brick, and stacked up until needed.

As soon as one set of the balusters was removed from the form, the form was re-assembled and a new set poured. This continued until enough balusters for the entire bridge were poured.

By referring to the plans for hand rail, Georgia Standard No. 3602, it will be noted that each baluster has a 3/8" Ø rod running through it, projecting from one end exactly $4\frac{1}{2}$". The reason for this exact dimension will be explained shortly.

The pouring of rail posts and rails proceeded as follows- forms for the rail posts were built on the ground, blocks being nailed inside the forms at top and bottom, thus leaving pockets in the post, when the forms were removed, into which the rails were to fit, then carried up and placed over the post reinforcing projecting from the curb.

After the post forms were plumbed and braced, elevations for the tops were given and chamfer strips nailed inside the forms at these elevations.

All posts and rails were such small sections that the concrete was shovelled into the forms instead of being dumped in, and extra care was used in spading the concrete.

Forms were removed in about 24 hours, and the posts were given a rubbed finish.

As soon as several rail posts were poured and rubbed up, forms were set for the rails between. The top forms had holes in the bottom at regular intervals through which the precast balusters projected when placed.

Each bottom form had three holes in it, through which the little 6"x6" concrete blocks to support the lower rail were poured. Of course, a small form had to be inserted under the bottom rail form for these blocks.

After the top and bottom rail forms were set and lined up, the balusters were threaded up through the holes in the top form, then allowed to slide down into the lower form until the 3/8" ∅ bar in each rested on the bottom of the lower form. The exact 4½" dimension specified for the lower projection of the baluster reinforcing bar, was for the purpose of getting an equal amount of every baluster embedded in the top and bottom rails.

The 4" concrete paving on the decks was the last concrete to be poured. It was poured and finished in accordance with the specifications, Division II for pavements, section 55.

The following table for foundation piles driven under bent 1 illustrates the method in which the necessary pile data was kept. This table is typical of the tables for the other bents.

On the "Plan and Elevation" sheet of the bridge plans is shown, as previously explained, a table of the lengths of piles in place under each bent that required foundation piles. For this reason it was not deemed necessary to take up space by including all the tables of pile data as kept during construction.

FOUNDATION PILE DATA TABLE

Date	Bent No.	Footing	Pile No.	Original Length	Cut Off	Penetration	Pay Cut Off	TEST DATA Drop	No Blows	Pene.	Pene. Per Blow	Bearing Capacity
5/22/27	1	Upstr	1	24'-8"	3'0"	21'-8"	3'0"	14'	5	6½"	1.3"	15 ton
"	"	"	2	24'-5"	2'2"	22'-3"	2'2"	13'	5	7½"	1.5"	13 "
"	"	"	3	24'-0"	2'6"	21'6"	2'6"	12'	5	7"	1.4"	12 "
"	"	"	4	2410"	3'5"	20-7"	3'5"	13'	5	7"	1.4"	13 "
"	"	"	5	24'-0"	2'11"	21'-1"	2'11"	13'	5	5½"	1.1"	15 "
"	"	"	6	24'-0"	0'3"	23'-9"	0	12'	5	4½"	0.9"	16 "
5/25/27	"	Center	1	25'-2"	2'9"	22'-5"	2'9"	13'	5	7"	1.4"	13 "
"	"	"	2	25'0"	1'7"	23'-5"	0	16'	5	15"	3.0"	10 "
"	"	"	3	25'-0"	1'4"	23'-6"	0	13'	5	7"	1.4"	13 "
"	"	"	4	25'-0"	3'8"	21'-4"	3'8"	13'	5	6½"	1.3"	14 "
"	"	"	5	25'-0"	3'3"	21'-9"	3'3"	12'	5	8"	1.6"	11 "
"	"	"	6	25'-10"	0'0"	25'-10"	0	12'	5	5½"	1.1"	14 "
5/13/27	"	Dnstr	1	* 16' + 15' + 16' =								
				47'-0"	1'7"	45'-5"	0	12'	5	6"	1.2"	14 "
"	"	"	2	* 16' + 16' =								
				32'-0"	3'1"	28'-11"	3'1"	12'	5	5"	1.0"	15 "
"	"	"	3	22'-6"	0'1"	22'-5"	0	16'	5	13"	2.6"	12 "
5/24/27	"	"	4	23'-2"	0'0"	23'-2"	0	16'	4	5½"	1.35"	15 "
"	"	"	5	25'-4"	0'1"	25'-3"	0	15½'	5	8½"	1.7"	14.4"
"	"	"	6	24'-2"	0'0"	24'-2"	0	12'	5	6"	1.2"	14 tons

*Note the first piles driven for bent 1 were driven 5/13/27 under the downstream footing. It was estimated 15' piles would be long enough, but this proved to be wrong. Pile No. 1 had to be spliced with a 15' pile then a 16' pile before it finally "took up" enough to have a computed bearing capacity of 14 tons. The original 16 ft. pile No. 2 had to be spliced also. Longer piles were obtained before any more were driven.

Space forbade the inclusion of many explanations such as length of time for falsework to remain in place, length of time for concrete to be mixed, and etc., but these requirements are all dealt with in the specifications which are included.

Several times during construction, the river rose and washed away falsework, cofferdams and etc., but accounts of these incidents were omitted in favor of facts pertinent to construction that the writer thought would be of more benefit to the reader.

Just before Christmas of 1927, an extreme cold wave froze the the river over. Later as the ice began to thaw and break up, a tremendous pressure was exerted against the falsework in the river, and several bents were washed out. These, of course, had to be replaced.

H. D. 9—10M—1-28

State Highway Board of Georgia

MONTHLY STATEMENT NO. 13-FINAL Project No. G-1-1 C

STATE AID ROAD BARTOW County

STATE OF GEORGIA County, Dr. TO J.B.McCRARY ENGR.CORP. Contractor

For work done on CARTERSVILLE-MARIETTA Road.

From Date of Beginning MAY9,1927 to JULY 7, 1928

Station	Itemized Statement of Quantities	Contract Price	Amount	
107x90	CONTRACT NO. 2			
2.08-0	842.08 Cu.Yds. Class A Conc.	22.50	18946.	80
1.48-0	263.48 " " " B Pier Shafts	21.50	5664	82
214.61-0	662.61 " " " " Bents etc.	21.50	14246	11
94-0	151906 Lbs Reinforcing Steel	.05	7595	30
3692.3-0	4232.3 Lin.Fts. Foundation Piles	1.00	4232	30
	1100 " " Type F Handrail	2.00	2200	00
	1100. Sq. Yds. 4" Conc. Paving	1.78	1958	00
233.1-0	1020.1 Cu. " Excav. # 1	4.50	4590	45
	Sub-Total		$59433	78
	Contingencies			
0	655.7 Lin Ftx. Foundation Piles Cut Off	.20	131	14
0	2340 Lbs. C.I.Grates & Drains	.05	117	00
	Force Accounts No. 1,2 & 3		674	48
	" " " 4		247	63
	" " " 5		87	60
	" " " 6		22	72
	Sub - Total		$ 1280	57

Final inspection made July 20 1928

and Project accepted

Checked with Plans and Contract

I hereby certify that this estimate is correct and the amounts are correct, due and unpaid.

Note: Prev. payment brought fwd. on #12 wrong and not paid. Error caught corrected on this ms.

Total $60714.35 Cost of bridge

Less 10% $

W.L.Robinson
Resident Engineer.

Less Previous Payment $ ~~52391.42~~ 52369.39

Amt. Due on Estimate $ ~~8322.93~~ 8344.96

Approved: [signature]
Division Engineer.

Less Rental on Cement Bins 50.00

~~8272.93~~

8294.96

Approved for payment:

Extended to 316 Days

Working days allowed in contract to complete 200

Actual working days consumed to date 316

[signature]
State Highway Engineer.

Plate 9

Plate 10

View of river frozen over in December of 1927

PAMPHLET "A"

GEORGIA STATE HIGHWAY DEPARTMENT

STANDARD SPECIFICATIONS

1928

DIVISION I

GENERAL REQUIREMENTS AND COVENANTS

DIVISION 1

GENERAL REQUIREMENTS AND COVENANTS

SECTION 1

1.00. **DEFINITION OF TERMS**

1.01. **"Definitions."** Wherever in these Specifications, Contract and Bond, the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows:

1.02. **"State."** The State of Georgia.

1.03. **"Board."** The State Highway Board as constituted under the laws of the State of Georgia.

1.04. **"Department."** The State Highway Department of Georgia.

1.05. **"County."** The County of the State of Georgia in which the work herein specified is to be done.

1.06. **"Board of County Commissioners."** The board of county commissioners or ordinary of the County.

1.07. **"Engineer."** The State Highway Engineer of the State of Georgia acting either directly or through his authorized assistants.

1.08. **"Resident Engineer."** The person acting as the authorized representative of the Engineer in the supervision and inspection of the work.

1.09. **"Inspector."** The authorized representative of the Engineer or Resident Engineer assigned to make detailed inspection of any or all portions of the work, or material thereof.

1.10. **"Bidder."** Any individual, firm, or corporation submitting a proposal for execution of work contemplated, or any portion thereof, acting directly or through an authorized representative.

1.11. **"Contractor."** The individual, firm, or corporation undertaking the execution of work under these specifications acting directly or through his agents or employees.

1.12. **"Surety."** The individual or corporate body which is bound with and for the Contractor, for the acceptable performance of the Contract and for his payment of all debts pertaining to the work. Where applying to the "Proposal Guaranty" it refers to the individuals or corporate body which engages to be responsible for the Bidder's acts in the execution of the Contract in the event of it being awarded to him.

1.13. **"Laboratory."** The testing laboratory of the State Highway Department or any other testing laboratory which may be designated by the Engineer.

1.14. **"Proposal."** The written proposal of the Bidder, on the form furnished, for the work contemplated.

1.15. **"Proposal Guaranty."** The security designated in the proposal, to be furnished by the Bidder as a guaranty of good faith to enter into a Contract if the work is awarded to him.

1.16. **"Plans."** The official approved plans, profiles, typical cross section, general cross sections, working drawings and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions, and details of the work to be done, and which are to be considered as a part of the Contract supplementary to these specifications.

1.17. **"Specifications."** The directions, provisions, and requirements contained herein as supplemented by such "Special Provisions" and "Supplemental Agreements" as may be necessary, pertaining to the method and manner of performing the work or to quantities and qualities of materials to be furnished under the contract. "Special Provisions" are intended to cover work appertaining to a particular project and proposed in the estimate, but not satisfactorily covered by these general specifications. Special Provisions will govern the work and take precedence over the general specifications wherever in conflict therewith. "Supplemental Agreements" are written agreements executed by the Contractor and Engineer, covering alternations and unforeseen work incidental and necessary to the project.

1.18. **"Instructions to Bidders."** All provisions, requirements and instructions pertaining to the method, manner, or time, of performing the work, payment therefor, or to the quantities and qualities of the materials prepared for the information of bidders submitting proposals.

1.19. **"Contract."** The agreement between the Contractor and the Board covering the performance of the work and the furnishing of materials in the construction of same. The Contract shall include the "Proposal," "Plans," "Specifications," "Special Provisions," and "Contract Bond," also any and all Supplemental Agreements which are required to complete the construction of the work in a substantial and acceptable manner.

1.20. **"Contract Bond."** The approved form of security furnished by the Contractor and his Surety as a guaranty of good faith on the part of the Contractor to execute the work in accordance with the terms of the Contract.

1.21. **"Right of Way."** The whole right of way which is reserved for and secured for use in constructing the roadway and its appurtenances.

1.22. **"Roadway."** The portion of the highway included between the outside lines of slopes, gutters, or side ditches, including also the appertaining structures, and all slopes, ditches, channels, waterways, etc., necessary to proper drainage and protection.

1.23. **"Roadbed."** That portion of the roadway between the inside edges of slopes of ditches and tops of fill slopes; the "subgrade" plus the "shoulders."

1.24. **"Sub-Grade."** That portion of the roadbed upon which the Surface Course or Pavement is to be placed.

1.25. **"Shoulders."** That portion of the roadbed between the inside edges of slopes of ditches in cuts and tops of fill slopes and the "Subgrade."

1.26. **"Bridges."** Structures having a length of more than twenty (20) feet measured along the center line of the road between the inside faces of abutments or end walls.

1.27. **"Culverts."** All waterway structures not defined as bridges.

1.28. **"Temporary Structures."** Any temporary structure or stream crossing, required to maintain traffic while constructing or reconstructing structures or parts of structures covered by the Contract.

The temporary structure shall include the earth approaches thereto.

1.29. **"Bridge Complete."** The entire structure, including both sub-structure and superstructure.

1.30. **"Substructure."** All of that part of the structure below the bridge seats or below the spring lines of concrete arches, parapets, backwalls and wingwalls of abutments shall be considered as parts of the substructure.

1.31. **"Superstructure."** All of that part of the structure above the bridge seats or above the spring lines of concrete arches, except as noted under "Substructure."

1.32. **"The Work."** All the work specified or mentioned herein or indicated on the plans, and as covered by the Contract.

1.33. **"Working Days."** Any Calendar day, exclusive of Sundays and legal holidays, on which the temperature, the weather or the condition of the soil does not make it impossible for the Contractor to make effective use of at least fifty per cent of the usual daily men hours during regular working hours.

SECTION 2

2.00. PROPOSAL REQUIREMENTS AND CONDITIONS

2.01. **Contents of Proposal Forms:** Bidders will be furnished with Proposal Forms which will state the location and description of the contemplated construction and will show the approximate estimate of the various quantities of work to be performed or materials to be furnished, with a schedule of items for which unit bid prices are asked, and the date and time and place of the opening of the Proposals. The "Notice to Contractors" and the "Special Provisions" will be attached to the Proposal Form.

2.02. **Interpretation of Estimates:** The quantities listed in the "Proposal Forms" are to be considered as approximate and are to be used only for the comparison of bids. Payment to the Contractor will be made only for the actual quantities of work performed in accordance with the plans and specifications and if, upon completion of the construction, the actual quantities shall show either increase or decrease from the quantities given in the approximate estimate, the unit bid prices mentioned in the proposal will still prevail, except as otherwise herein provided for. The right is reserved to increase or decrease any or all of the amounts given in the estimate of approximate quantities as shown in the "Proposal Form," and it is understood that the length of the improvement, the quantities of work to be done, and materials to be furnished may be increased or diminished not exceeding twenty (20) per cent of the total length of the improvement or of the total amount of the Contract, without in anyway invalidating the bid prices.

2.03. **Examination of Plans, Specifications, Special Provisions, and Site of Work:** The bidder is required to examine carefully the site of, and the Proposal, Plans, Specifications and Contract Form for the work contemplated, and it will be assumed that he has judged for and satisfied himself as to the conditions to be encountered, as to the character, quality and quantities of work to be performed and the materials to be furnished, and as to the requirements of these specifications, Special Provisions and Contract.

2.04. **Preparation of Proposal:** The Bidder must submit his proposal on the form above described. The blank spaces in the proposal must be filled in correctly, where indicated, for each and every item for which a quantity is given, and the Bidder must state the prices (written in ink, both in words and numerals) for which he proposes to do each item of the work contemplated. The Bidder shall sign his proposal correctly. If the proposal is made by an individual, his name and post office address must be shown. If made by a firm or partnership, the name and post office address of each member of the firm or partnership must be shown. If made by a corporation, the person signing the proposal must show the name of the State under the laws of which the corporation was chartered and the names, titles and business addresses of the President, Secretary and Treasurer.

2.05. **Rejection of Proposals Containing Alterations, Erasures or Irregularities:** Proposals may be rejected if they show any alteration of form, additions not called for, conditional or unauthorized alternate bids, incomplete bids, erasures, or irregularities of any kind.

2.06. **Proposal Guaranty:** No proposal will be considered unless accompanied by a certified or cashier's check in the amount as specified in the proposal form and made payable to the party specified.

2.07. **Delivery of Proposals:** Each proposal shall be placed, together with the proposal guaranty, in a sealed envelope so marked as to indicate its contents without being opened. This envelope shall then be placed in another which shall be sealed and addressed as indicated in the "Notice to Contractors." Proposals will be received on the hour and date set for the opening thereof and must be in the hands of the officials indicated by that time.

2.08. **Withdrawal of Proposals:** A Bidder may withdraw his proposal provided the request in writing is in the hands of the official indicated in the "Notice to Contractors" by the time set for opening proposals. When such proposal is reached, it will be returned to the Bidder unread.

2.09. **Public Opening of Proposals:** Proposals will be opened and read publicly at the time and place indicated in the "Notice to Contractors." Bidders or their authorized agents are invited to be present.

2.10. **Disqualification of Bidders:** More than one proposal from an individual, a firm or partnership, a corporation or an association under the same or different names will not be considered. Reasonable ground for believing that any Bidder is interested in more than one proposal for the work contemplated will cause the rejection of all proposals in which such Bidder is interested. Any or all proposals will be rejected if there is reason for believing that collusion exists among the Bidders and all participants in such collusion will not be considered in future proposals for the same work. Proposals in which the prices obviously are unbalanced may be rejected. No contract will be awarded except to responsible Bidders capable of performing the class of work contemplated.

2.11. **Competency of Bidders:** Bidders must be capable of performing the various items of work bid upon. They will be required to furnish a statement, on form furnished by the Board forty-eight (48) hours before bids are to be received, covering experience on similar work, a list of machinery, plant and other equipment available for the proposed work, and such statements of their financial resources as may be deemed necessary.

2.12. **Material Guaranty:** Before any Contract is awarded, the Bidder may be required to furnish a complete statement of the origin, composition and manufacture of any or all materials to be used in the construction of the work, together with samples, which samples may be subjected to the tests provided for in these Specifications to determine their quality and fitness for the work.

SECTION 3

3.00. AWARD AND EXECUTION OF CONTRACT.

3.01. **Consideration of Proposals:** For the purpose of award after the Proposals are opened and read the correct summation of the products of the approximate quantities shown in the Proposal, by the unit bid prices will be considered the amount of the bid. The amounts will then be compared and the results of such comparison will be immediately made public. Until the final award of the Contract, however, the right will be reserved to reject any and all proposals and to waive technical errors as may be deemed best for the interests of the State.

3.02. **Award of Contract:** The award of the Contract, if it be awarded, will be to the lowest responsible Bidder whose proposal shall comply with all the requirements necessary to render it formal. The award, if made, will be within thirty (30) days after the opening of the proposals, but in no case will an award be made until all necessary investigations are made into the responsibility of the Bidder to whom it is proposed to award the Contract.

3.03. **Return to Proposal Guaranties:** As soon as the bid prices have been compared, the Board may, at their discretion, return the guaranty deposits accompanying such proposals as in their judgment, would not likely be considered in making the award. All other proposal guarantees will be held until the contract and bond have been executed, after which they will be returned to the unsuccessful Bidders. In no case will a proposal guarantee be held longer than fifteen (15) days without the Bidders consent. Should no award be made within thirty (30) days, all proposals will be rejected and proposal guarantees returned.

3.04. **Requirement of Coutract Bond:** The Bidder to whom the Contract is awarded shall, within fifteen (15) days from the date of the award, furnish and file with the Board an acceptable surety bond as required by law. Such bond shall be of the form prescribed and shall meet all requirements of the laws of Georgia. All proposals shall be submitted on the basis of furnishing a bond executed by a corporate surety company of recognized standing, having a Resident Agent in the State of Georgia, and all proposals, otherwise submitted may be rejected as irregular.

3.05. **Execution of Contract:** The individual, firm or corporation to whom the Contract has been awarded shall execute and file with the Board the required number of copies of the contract within fifteen (15) days after the date of the award.

3.06. **Approval of Contract:** All contracts requiring the approval of the Board shall have such approval noted thereon before any construction work is started. Any materials delivered or work started before such approval is noted on the Contract is entirely at the Contractor's risk. The approval of a Contract is stipulated to include the approval of the specific Contract, Contractor's Bond, Plans, Specifications, Working and Shop Drawings and Special Provisions for all structures included in the Contract.

3.07. **Failure to Execute Contract:** In case of failure on the part of the Contractor to enter into Contract and furnish bond as above required, the proposal guaranty accompanying the Proposal will become the property of the State as liquidated damages. Award may then be made to the next lowest bidder or the work may be re-advertised at the discretion of the Board.

SECTION 4

4.00. SCOPE OF WORK

4.01. **Intent of Plans and Specifications:** The intent is to prescribe a complete work or improvement which the Contractor undertakes to do, in full compliance with the Plans, these Specifications, the Special Provisions, Proposal and Contract. The Contractor shall perform all Earth Work, construct all Surface Sources, build all Structures and Incidental Construction, and perform Extra Work, all in accordance with the lines, grades, typical cross section and dimensions shown on the Plans. He shall furnish, unless otherwise provided in the Special Provisions or in the Contract, all materials, implements, machinery, equipment, tools, materials, supplies and labor necessary to the prosecution and completion of the work.

4.02. **Special Work:** Proposed construction or requirements not covered by these Specifications will be covered by "Special Provisions" and performed or complied with by the Contractor as herein provided.

4.03. **Alteration of Plans, Quantities or of Character of Work:** The Engineer reserves the right to make such alterations in the plans or in the quantity of the work as may be considered necessary or desirable during the progress of the work to complete fully and perfectly the proposed construction, provided such alterations do not change materially the original Plans and Specifications, or alter the length of the improvement, or the total amount of the Contract more than twenty (20) per cent. Such alterations shall not be considered as a waiver of any conditions of the Contract nor invalidate any of the provisions thereof. The Contractor shall perform the work as increased or decreased and no allowance will be made for anticipated profits.

4.04. **Extra Work:** Unforeseen work made necessary by alteration of plans or of work, or by other reasons, involving increased or decreased unit cost to Contractor, or work necessary to complete the proposed improvement, for which no price is provided in the Contract, shall be deemed "Extra Work" and shall be performed by the Contractor in accordance with the specifications and as directed; provided, however, that before any "Extra Work" is started a "Supplemental Agreement" shall be signed by both contracting parties or a written order from the Engineer to do the work on a Force Account Basis given the Contractor.

4.05. **Maintenance of Detours:** The construction and maintenance of necessary detours will be performed by the County or State, but may, at the discretion of the Engineer, be required of the Contractor and paid for on a force account basis. The right of way will be provided by the County. The Contractor will not be required to construct or maintain the temporary crossing structures unless such crossings are stipulated in the Contract or ordered as extra work by the Engineer. If the building of a temporary crossing is included in the Contract the responsibility of the Contractor for accidents to the public or his workmen, arising from its construction or maintenance, shall extend to such structure and its roadway approaches.

4.06. **Removal and Disposal of Structures and Obstructions:** All fences, buildings, structures of any character not necessary to the construction of the roadway, or other encumberances upon or within the limits of the right of way shall be removed by the Contractor and carefully placed on the abutting property or otherwise disposed of, if and as required. This work will be paid for as "Extra Work," except as otherwise provided in these Specifications.

4.07. **Rights in and Use of Materials Found on the Work:** The Contractor, with the approval of the Engineer, may use in the proposed construction suitable stone, gravel, sand or other material found in the "Excavation," and will be paid for the excavation of such materials at the contract unit price therefor, but he shall replace at his own expense with other suitable material all of that portion of the material so removed and used as was contemplated for use in the embankments, backfills, approaches, or otherwise. No charge for materials so used will be made against the Contractor except the replacement herein provided for. The Contractor shall not excavate or remove any material from within the highway location which is not within the excavation, as indicated by the slope and grade lines, without written authorization from the Engineer.

4.08. **Final Cleaning Up:** Upon completion and before final acceptance, the Contractor shall remove all falsework, excavated or useless materials, rubbish and temporary buildings, replace or renew any fences damaged and restore in an acceptable manner all property, both public and private, which may have been damaged during the prosecution of the work, and shall leave all parts of the work in a neat and presentable condition satisfactory to the Engineer. All excavated material or false-work placed in the stream channel during construction shall be removed by the Contractor before final acceptance. Placing material on abutting property with or without the consent of the owner shall not be considered a satisfactory disposal.

SECTION 5

5.00. CONTROL OF THE WORK.

5.01. **Authority of Engineer:** The work shall be done under the direct supervision of the Engineer. The Engineer shall decide any and all questions which may arise as to the quality or acceptability of materials furnished and work performed and as to the manner of performance and rate of progress of the work and shall decide all questions which may arise as to the interpretation of the Plans and Specifications, and all questions as to the acceptable fulfillment of the Contract on the part of the Contractor.

5.02. **Plans and Working Drawings:** General drawings, showing such details as are necessary to give a comprehensive idea of the construction contemplated, will be shown in the general plans but the Contractor shall submit to the Engineer for approval such additional detailed shop or working drawings as may be required for the construction of any part of the work, and prior to the approval of such plans any work done or material ordered shall be at the Contractor's risk.

Working drawings for steel structures shall consist of shop detail, erection and other working plans showing details, dimensions, sizes of material and other information necessary for the complete fabrication and erection of the metal work.

Working drawings for concrete structures shall consist of such detailed plans as may reasonably be required for the successful prosecution of the work and which are not included in the plans furnished by the Engineer. These may include plans for falsework, bracing, cribs, cofferdams, centering and form work, masonry layout diagrams and diagrams for bent reinforcement steel.

It is expressly understood that the approval by the Engineer of the Contractor's working drawings relates to the requirements for strength and detail and such approval will not relieve the Contractor from responsibility for errors in dimensions.

The Contractor shall furnish the Engineer with such blue-print copies of the working drawings as may be required for approval and construction purposes and upon completion of the work the original tracings, if required, shall be supplied to the Engineer.

The Contract price shall include the cost of furnishing all working drawings and the Contractor will be allowed no extra compensation for such drawings.

5.03. **Conformity with Plans and Allowable Deviations:** Finished surfaces in all cases shall conform with lines, grades, cross sections and dimensions shown on the approved plans. The crown, or rise of the finished surface of the roadway from the curb or side line to the center line, shall be as shown on the typical cross section of the plans except at intersecting highways or wherever, to insure correct drainage or for other reasons, changes may be directed. Where deemed necessary the Contractor may be required to superelevate the roadway. Such other deviations from the Plans, approved working drawings and Specifications as may be required by the exigencies of construction, will in all cases be determined by the Engineer and authorized in writing.

5.04. **Co-ordination of Specificatious and Plans:** In the event of any discrepancy between the drawings and figures written thereon the figures are to be considered as correct. In the case of any discrepancy between the drawings and the Specifications, the drawings are to govern. If there is a discrepancy between the general specifications and the supplemental specifications, the supplemental specifications are to govern.

The Contractor shall take no advantage of any apparent error or omission in the Plans or Specifications but the Engineer shall be permitted to make such corrections and interpretations as may be deemed necessary for the fulfillment of the intent of the Plans and Specifications.

5.05. **Co-operation of Contractor:** The Contractor will be supplied with two copies of the Plans, Specifications and Special Provisions, and he shall have available on the work at all times one copy each of said Plans and Specifications and Special Provisions. He shall give the work his constant attention to facilitate the progress thereof and shall co-operate with the Engineer in every way possible. He shall have at all times a competent and reliable English-speaking representative on the work authorized to receive orders and to act for him. Such representative shall be present on the work irrespective of the amount of work sublet.

5.06. **Construction Stakes:** The Engineer will furnish and set construction stakes establishing lines and continuous profile grade in road work, and center line and benchmark for bridge work, and will furnish the Contractor with all necessary information relating to lines and grades. The Contractor shall furnish, free of charge, all additional stakes, all templates and other materials necessary for marking and maintaining points and lines given, and shall furnish the Engineer such labor as he may require in establishing points and lines necessary to the prosecution of the work. The Contractor shall be held responsible for the preservation of all stakes and marks and if, in the opinion of the Engineer, any of the construction stakes or marks have been carelessly or wilfully destroyed or disturbed by the Contractor, the cost of replacing them shall be charged against him and shall be deducted from the payment for the work.

5.07. **Authority and Duties of Inspectors:** Inspectors, employed by the Board shall be authorized to inspect all work done and all material furnished. Such inspection may extend to all or any part of the work and to the preparation or manufacture of the materials to be used. An Inspector shall be stationed on the construction to report to the Engineer as to the progress of the work and the manner in which it is being performed; also to report whenever it appears that the materials furnished and the work performed by the Contractor fail to fulfill the requirements of the Specifications and Contract, and to call to the attention of the Contractor any such failure or other infringement; but such inspection shall not relieve the Contractor from any obligation to perform all of the work in accordance with the requirements of the Specifications. In case of any dispute arising between the Contractor and the Inspector as to materials furnished or the manner of performing the work, the Inspector shall have the authority to reject materials or suspend the work until the question at issue can be referred to and decided by the Engineer. The Inspector shall not, however, be authorized to revoke, alter, enlarge, relax or release any requirements of these Specifications, nor to approve or accept any portion of work, nor to issue instructions contrary to the Plans and Specifications.He shall in no case act as foreman or perform other duties for the Contractor, nor interfere with the management of the work. Any advise which the Inspector may give the Contractor shall in no wise be construed as binding the Engineer in any way, or as releasing the Contractor from the fulfillment of the terms of the Contract.

5.08. **Inspection:** The Contractor shall furnish the Engineer with every reasonable facility for ascertaining whether or not the work as performed is in accordance with the requirements and intent of the Specifications and Contract. If the Engineer requests it, the Contractor shall, at any time before acceptance of the work, remove or uncover such portions of the finished work as may be directed. After examination the Contractor shall restore said portions of the work to the standard required by the Specifications. Should the work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed, shall be paid for as "Extra Work," but should the work so exposed or examined prove unacceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed, shall be at the Contractor's expense. No work shall be done nor materials used without suitable supervision or inspection by the Engineer or his representative.

When the United States Government is to pay a portion of the cost of the work covered by this contract, the work shall be subject to the inspection of the representative of the Federal Government. Such inspection shall in no sense make the Federal Government a party to this Contract, and will in no way interfere with the rights of either party hereunder.

5.09. **Removal of Defective aud Unauthorized Work:** All work which has been rejected shall be remedied or removed and replaced in an acceptable manner by the Contractor at his own expense, and no compensation shall be allowed him for such removal or replacement. Work done beyond the lines and grades shown on the plans or as given, except as herein provided, or any extra work done without written authority will be considered as unauthorized and at the expense of the Contractor, and will not be measured or paid for. Work so done may be ordered removed at the Contractor's expense. Upon failure on the part of the Contractor to forthwith comply with any order of the Engineer made under the provisions of this article, the Engineer shall have authority to cause Defective Work to be remedied, or removed and replaced, and unauthorized work to be removed and such costs to be deducted from any monies due or to become due the Contractor.

5.10. **Final Inspection:** Unless otherwise provided, the Engineer shall make final inspection within ten (10) days after notification by the Contractor or his superintendent that the work is completed. If the work is not acceptable to the Engineer he shall advise the Contractor as to the particular defects to be remedied before final acceptance can be made.

SECTION 6

6.00. **CONTROL OF MATERIAL.**

6.01. **Source of Supply and Quality of Materials:** The source of supply of each of the materials shall be approved by the Engineer before the delivery is started. Representative preliminary samples of the character and quantity prescribed shall be submitted by the Contractor or producer without charge for examination and tested in accordance with the methods referred to under tests of samples of materials in paragraph 1.6.02. Only materials conforming to the requirements of these Specifications and approved by the Engineer shall be used in the work. All materials proposed to be used may be inspected or tested at any time during their preparation and use. If, after trial, it is found that sources of supply which have been approved do not furnish a uniform product, or if the product from any source proves unacceptable at any time, the Contractor shall furnish approved material from other approved sources. No material which, after approval, has in any way become unfit for use shall be used in the work.

6.02. **Samples and Tests:** Tests of all material specified will be made by the Engineer in accordance with the official approved methods "Prescribed by the American Society for Testing Materials" or in accordance with requirements of U. S. Department of Agriculture Bulletin, No. 1216 of May, 1924, with subsequent revisions. When tests are made at places other than the Laboratory, the Contractor shall furnish every facility for the verification of all scales, measures and other devices which he operates. In the case of Bituminous Macadam, Bituminous Concrete, Sheet Asphalt or other hot mixed surfaces or Concrete Pavement or Concrete Base projects, the Contractor shall provide a suitable shelter for the Inspector on duty at the paving plant, to protect him from the weather while conducting the necessary test of materials used. The room shall be heated to a temperature of at least 60° F. if the work is in progress in cold weather.

6.03. **Storage of Materials:** Materials shall be stored so as to insure the preservation of their quality and fitness for the work. Stored materials shall be located so as to facilitate prompt inspection.

6.04. **Defective Materials:** All materials not conforming to the requirements of these Specifications shall be considered as defective, and all such materials, whether in place or not, shall be rejected and shall be removed immediately from the site of the work, unless otherwise permitted by the Engineer. No rejected material, the defects of which have been subsequently corrected, shall be used until approval has been given. Upon failure on the part of the Contractor to forthwith comply with any order of the Engineer made under the provisions of this article the Engineer shall have authority to remove and replace defective material and to deduct the cost of removal and replacement from any monies due or to become due the Contractor.

6.05. **Materials Furnished by State:** When so indicted in the advertisement for proposals, bidders shall submit unit prices as follows:

One price to include all labor, material, equipment with the exception of cement, slag, gravel, crushed stone, bituminous or other designated materials, which materials will in such cases be furnished by the State under the following conditions:

1. The designated material will be furnished, without charge, F. O. B., any approved designated delivery point in the County in which the work is situated.

2. Shipments of materials shall be ordered by the Contractor as the progress of the work warrants. Written authorization for ordering will be furnished by the Board to the Contractor, on which will be indicated the company from whom the material is to be ordered.

3. It is expressly understood by the Contractor that no responsibility is assumed by the Board for the delivery of the material at the time desired, and that no extra compensation will be allowed the Contractor for delays.

4. The Contractor shall assume responsibility for all demurrage charges, and he shall be prepared to unload and properly protect all material from weather, dampness, or other destructive agencies. If any material is damaged or lost subsequent to the breaking of the car door seal or receipt of material by the Contractor, he shall be charged with the value of such material including freight charges, and it is hereby agreed that all such amounts are to be withheld from any sums that may be due the Contractor under the terms of this Contract.

5. The Contractor shall give the company furnishing material shipping instructions within a reasonable time before the material shall be required. The company will, within a reasonable time after the receipt of shipping instructions, ship the material as it is required by the progress of the work, unless prevented from so doing by strikes, car shortage, or other conditions beyond the control of the company.

6. If for any reasons other than those mentioned herein the material is not delivered within three (3) full working days of the time required, the Contractor may, with the written consent of the Board, purchase the material in the open market, and he shall be allowed therefor the prevailing net market price.

7. From the time the seal is broken on the freight car door, the Contractor shall be come responsible for all cloth cement sacks in the car and shall be charged therefor by the Board the same price that the State is obliged to pay for such sacks and such charges shall be withheld from sums eventually due the Contractor.

SECTION 7

7.00. LEGAL REGULATIONS AND RESPONSIBILITY TO THE PUBLIC

7.01. **Laws to be Observed:** The Contractor is assumed to have made himself familiar with and at all times shall observe and comply with all Federal and State laws and local by-laws, ordinances and regulations in any manner affecting the conduct of the work, and shall indemnify and save harmless the Board and its representatives against any claim arising from the violation of any such law, by-law, ordinance or regulations whether by himself or by his employees.

7.02. **Permits and Licenses:** The Contractor shall procure all permits and licenses, pay all charges and fees, and give all notices necessary and incident to the due and lawful prosecution of the work.

7.03. **Patented Devices, Materials and Processes:** If the Contractor desires to use any design, device, material, or process covered by letters patent or copyright, he shall provide for such use by suitable legal agreement with the patentee or owner and a copy of this agreement shall be filed with the Board; if no such agreement is made or filed as noted, the Contractor and the Surety shall indemnify and save harmless the Board from any and all claims for infringement by reason of the use of any such patented design, devices, material or process, or any trade mark or copyright in connection with the work agreed to be performed under the Contract, and shall indemnify the Board for any costs, expenses and damages which it may be obliged to pay, by reason of any such infringement, at any time during the prosecution or after the completion of the work; provided, however, that the Board hereby assumes the responsibility to defend any and all suits brought for the infringement of any patent claimed to be infringed by the design, type of construction or material provided for in plans furnished the Contractor by the Board and to hold the Contractor harmless on account of such suits.

7.04. **Restoration of Surfaces Opened by Permit:** The Contractor shall not allow any party to make an opening in the highway unless a duly authorized permit is presented. Until the acceptance of the work to be performed under the Contract, the Contractor shall make all necessary repairs in an acceptable manner, at any point in the roadway where any opening has been made by due authority. Such repair work will be paid for by the party to whom the permit is issued on the basis of "Extra Work" as provided for in these Specifications, and said work shall be subject to the same conditions as the original work performed.

7.05. **Sanitary Provisions:** The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of his employees as may be necessary to comply with the requirements and regulations of the State Department of Health or of other authorities having jurisdiction. He shall commit no public nuisance.

7.06. **Public Convenience and Safety:** The safety of the general public along or near the road and the convenience of traffic are to be regarded as of prime importance. If the Contractor constructs temporary bridges or provides temporary stream crossings, his responsibility for accidents shall include the roadway approaches as well as the structures of such crossings. Materials stored upon the highway shall be placed so as to cause as little obstruction to the traveling public as is considered necessary. No section of road shall be closed to the public except by express permission of the Engineer. When the road under construction is being used by the traveling public, especial attention shall be paid to keeping both the subgrade and newly laid surfacing in such condition that the public can travel over same in comfort and safety. The Contractor shall, at his own expense, "road machine" the subgrade and all courses adapted to such treatment when and as directed by the Engineer. When so provided on the typical cross section, and directed by the Engineer, Concrete Base, Concrete Pavement, and other suitable pavements shall be constructed one-half at a time, opened and maintained for traffic. The Contractor shall co-operate with the Engineer in the regulation of traffic.

7.07. **Barricades, Danger, Warning and Detour Signs:** The Contractor shall, at his own expense, provide, erect and maintain all necessary barricades, suitable and sufficient red lights, danger signals and signs, a sufficient number of watchmen and take all necessary precautions for the protection of the work and safety of the public. Highways closed to traffic shall be protected by effective barricade on which shall be placed acceptable warning signs. All barricades and obstructions shall be illuminated at night and all lights for this purpose shall be kept burning from sunset to sunrise.

7.08. **Use of Explosives:** When the use of explosives is necessary for the prosecution of the work, the Contractor shall use the utmost care not to endanger life or property. All explosives shall be stored in a secure manner and all storage places shall be marked clearly "DANGEROUS EXPLOSIVES" and shall be in care of competent watchmen at all times.

7.09. **Preservation and Restoration of Property, Trees, Monuments, Etc.:** The Contractor shall be responsible for the preservation of all public and private property, trees, monuments, etc., along and adjacent to the roadway and shall use every precaution necessary to prevent damage or injury thereto. He shall use suitable precaution necessary to prevent damage to pipes, conduits, and other underground structures and shall protect carefully from disturbance or damage all land monuments and property marks until an authorized agent has witnessed or otherwise referenced their location and shall not remove them until directed. The Contractor shall not injure or destroy trees or shrubs nor remove or cut them without proper authority. When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work, or in consequence of the non-execution thereof on the part of the Contractor, he shall restore at his own expense, such property to a condition similar or equal to that existing before such damage or injury was done, by repairing, rebuilding, or otherwise restoring same, or he shall make good such damage or injury in an acceptable manner.

7.10. **Responsibility for Damage Claims, Etc.:** The Contractor shall save harmless the Board and all of its representatives from all suits, actions or claims of any character brought on account of any injuries or damages sustained by any person or property in consequence of any neglect in safeguarding the work, or through the use of unacceptable materials in the construction of the improvement or on account of any act or omission, by the said Contractor, or on account of any claims or amounts recovered for any infringement of patent, trade mark or copyright, except as herein elsewhere specifically provided, or from any claims or amounts arising or recovered under the "Workmen's Compensation Law," or any other law, by-law, ordinance, order or decree. He shall be responsible for all damage or injury to property of any character during the prosecution of the work resulting from any act, omission, neglect or misconduct in his manner or method of executing said work satisfactorily, or due to his nonexecution of said work or at any time due to defective work or materials. He shall not be released from said responsibility until the roadway shall have been completed and accepted and so much of the money due the said Contractor under and by virtue of his Contract as shall be considered necessary by the Board may be retained for the use of the State or surety may be held until such aforesaid claims have been settled and suitable evidence to that effect furnished to the Board.

7.11. **Compensation for Unreasonable Delays:** If unreasonable delays occur in reaching a settlement with the Contractor on changes made in the Plans or Specifications due to a failure of the Enginner to act, or if there are delays due to a failure to provide the necessary stakes after a forty-eight (48) hour notice in writing to the Engineer that such stakes are needed, the Contractor shall be compensated for any loss sustained.

7.12. **Contractor's Responsibility for Work:** Until the acceptance of the work by the Engineer as evidenced in writing, it shall be under the charge and care of the Contractor. He shall take every necessary precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or from the non-execution of the work. The Contractor shall rebuild, repair, restore and make good, at his own expense, all injuries or damages to any portion of the work occasioned by any of the above causes before its completion and acceptance. In case of suspension of work from any cause whatever the Contractor shall be responsible for all materials, and shall properly store them if necessary; he shall provide suitable drainage of the roadway and erect temporary structures where necessary.

The Contractor will be required to maintain the road in first-class condition after its completion for a period of thirty (30) days before final acceptance; except that the Engineer, may, in his discretion, release the Contractor from the further maintenance of completed sections of the road, not less than two miles in length, which have been satisfactorily maintained under traffic for at least thirty (30) days. Satisfactory maintenance of pavements shall include filling all cracks which may occur before final acceptance with an approved material.

7.13. **Personal Liability of Public Officials:** In carrying out any of the provisions of these Specifications or in exercising any power or authority granted to him by this Contract there shall be no liability upon the Engineer or his authorized assistants, either personally or as an official of the State, it being understood that in such matters he acts as the agent and representative of the State.

7.14. **No Waiver of Legal Rights:** The State shall not be precluded or estopped by any measurement, estimate, or certificate made either before or after the completion and acceptance of the work and payment therefor, from showing the true amount and character of the work performed and materials furnished by the Contractor, or from showing that any such measurement, estimate, or certificate is untrue or incorrectly made, or that the work or materials do not conform in fact to the Contract. The State shall not be precluded or estopped notwithstanding any such measurement, estimate, or certificate, and payment in accordance therewith from recovering from the Contractor, and his sureties, such damages as it may sustain by reason of his failure to comply with the terms of the Contract. Neither the acceptance of the Board, of any representative of the Board, nor any payment for acceptance of the whole or any part of the work, nor any extension of time, nor any possession taken by the Board, shall operate as a waiver of any portion of the Contract or of any power herein reserved, or any right to damages herein provided. A waiver of any breach of the Contract shall not be held to be a waiver of any other or subsequent breach.

7.15. **Arbitration:** Both parties to the contract agree that as a condition precedent to the filing of an action in any court involving the amount or rate of payment or settlement for work performed by the Contract under these Specifications and Contract, and as a condition precedent to the liability of the Board for any amount other than contained in the estimates approved by the Engineer, any question at issue involving the amount or rate of settlement or liability of the State for an amount other than as shown by the estimates approved by the Engineer, shall be referred to a board of arbitration for decisions and award. Said board of arbitration shall consist of three persons, one to be chosen by the State Highway Board, one by the Contractor, and the third by these two. The board of arbitration shall make such rules as it shall determine equitable to govern itself in the conduct of the investigation and determination of the award. In determing the award, the majority of the board of arbitration shall govern, and the parties to the Contract shall be bound by the findings of said board of arbitration, certified copies of which findings and award shall be filed with the State Highway Board and Contractor. The board of arbitration shall fix the amount of the cost of the proceedings, including a fair and reasonable compensation to the arbitration board members and shall determine how the total cost shall be borne. The authority of the board of arbitration shall not extend to the interpretation of the Plans and Specifications, or the determination of the qualities of the materials or workmanship furnished by the Contractor. The board of arbitration shall have no authority to set aside or to modify the terms or requirements of the Contract. The board of arbitration shall have authority only to pass upon questions involving compensation to the Contractor for work actually performed but not allowed by the Engineer.

SECTION 8

8.00. PROSECUTION AND PROGRESS

8.01. **Subletting or Assigning of Contract:** The work awarded shall be performed by the Contractor to whon the award is made, with the assistance of workmen under his immediate superintendence, and the Contract shall not be sublet, assigned, or otherwise disposed of, either in whole or in part, except with the written consent of the Engineer.

8.02. **Prosecution of Work:** The Contractor shall begin the work to be performed under the Contract on such date as is stipulated in the "Notice to Contractors." The Contractor shall notify the Engineer at least forty-eight (48) hours before beginning work. He shall start the work at the part of the road designated by the Engineer and shall prosecute the work at as many different points as the Engineer shall direct.

8.03. **Limitations of Operations:** The Contractor shall at all times conduct the work in such manner and in such sequence as will insure the least practicable interference with traffic and he shall have due regard to convenient detours. He shall not open up work to the prejudice of work already started and in this feature of the prosecution of the work shall be governed by the orders of the Engineer.

8.04. **Character of Workmen and Equipment:** The Contractor shall employ only competent and efficient laborers, mechanics, or artisans and whenever, in the opinion of the Engineer, any employee is careless or incompetent, or obstructs the progress of the work, or acts contrary to instructions, or conducts himself improperly, the Contractor shall upon complaint of the Engineer discharge or otherwise remove him from the work, and not employ him again upon it.

The methods, equipment and appliances used on the work shall be such as will produce a satisfactory quality of work and shall be adequate to complete the Contract within the time limit specified.

8.05. **Preference for Honorably Discharged Soldiers, Sailors and Marines:** In the employment of labor in the performance of this Contract preference shall be given, other things being equal, to honorably discharged soldiers, sailors, and marines, but no other preference or discrimination among citizens of the United States shall be made. (Act of Feb. 28th, 1919, No. 299, 65th Congress.)

8.06. **Temporary Suspension of Work:** The Engineer shall have the authority to suspend the work wholly or in part, for such period as he may deem it necessary, due to unsuitable weather, or to such other conditions as are considered unfavorable for the suitable prosecution of the work, or for such time as he may deem necessary due to the failure on the part of the Contractor to carry out orders given, or to perform any provision of the Contract. The work shall be resumed when conditions are favorable or when corrective measures satisfactory to the Engineer have been applied, when and as ordered by the Engineer in writing. The Contractor shall not suspend the work without authority.

8.07. **Determination and Extension of Contract Time:** If the satisfactory execution of the Contract shall require work or materials in greater amounts or quantities than those set forth on the plans, then the contract time may be increased by such an amount as may be determined by the Engineer. Extensions to the Contract time may be granted for other reasons, at the discretion of the Engineer. No allowance shall be made for delay or suspension of the work due to the fault of the Contractor.

In contracts specifying a certain number of working days for completion, allowance shall be made in computing the contract time for all days during which the prosecution of the work has been delayed by unsuitable weather conditions, storms, acts of Providence, act or omissions of the Board or Engineer but not by any fault of the Contractor, or by any other causes entirely beyond his control. Sundays and legal holidays shall not be computed as working days.

All requests for extension of time in which to perform the Contract shall be submitted in writing by the Contractor to the Engineer.

8.08. **Failure to Complete Work on Time:** If any work shall remain uncompleted after elapse of the time specified in the Proposal and Contract as adjusted by the Engineer for the completion of the work provided for in the Contract, there shall be deducted from the monies due the Contractor, not as a penalty but as liquidated damages, the amounts as fixed in the following schedule:

Amount of Original Proposal	Amount of Liquidated Damages Per Day
$20,000.00 and less	$10.00
$20,000.00 and less than $50,000.00	20.00
$50,000.00 and less than $100,000.00	30.00
$100,000.00 or more	50.00

8.09. **Completion of Work Ahead of Contract Time:** Should the work be completed to the satisfaction of the Engineer prior to the time agreed upon in the Contract, the sum per day given in the schedule in paragraph 8.08, unless otherwise specified in the proposal form, shall be paid to the Contractor for each day saved from the Contract time.

8.10. **Annulment of Contract:** The Contract of which these Specifications form a part may be annulled by the Board for any one of the following reasons: Substantial evidence that the progress being made by the Contractor is insufficient to complete the work within the specified time, failure on the part of the Contractor to observe the requirements of these Specifications, or failure on the part of the Contractor promptly to make good any defects in materials or workmanship that may be pointed out to him by the Engineer, or in case the Contractor shall become insolvent or declared bankrupt, or allow any final judgment to stand against him unsatisfied, or shall make an assignment for the benefit of creditors.

Before the Contract is annulled, the Contractor and his bondsmen will first be notified in writing by the Engineer of the conditions which make annulment to the Contract imminent. Fifteen (15) days after this notice is mailed to the address given in the Proposal, if in the judgment of the Engineer no effective effort has been made by the Contractor to correct the condition complained of then the Board may declare the Contract annulled and notify the Contractor and his bondsmen accordingly.

Upon receipt of a notice from the Board that the Contract has been annulled, the Contractor shall immediately discontinue all operations. The Board may then proceed with the work, in any lawful manner that it may elect, until same is finally completed.

When the work which was covered by the Contract is thus finally completed, the total cost of the same will be computed. If this total cost is less than the contract price, any money due the Contractor will be paid to him. If the total cost is greater than the contract price, the difference shall be paid to the Board either by the Contractor or his surety.

8.11. **Termination of Contractor's Responsibility:** This Contract will be considered complete when all work has been completed, the Final Inspection made, and the work accepted by the Engineer, and the final estimate paid. The Contractor will then be released from further obligation except as set forth in his bond.

SECTION 9

9.00. MEASUREMENT AND PAYMENT.

9.01. **Measurement of Quantities:** All work completed under the Contract shall be measured by the Engineer according to United States Standard Measures, unless otherwise agreed upon in writing. All longitudinal measurements for area will be made along the actual surface of the roadway and not horizontally, and no deduction will be made for fixtures in the roadway having an area of nine (9) square feet, or less.

9.02. **Measurement of Asphalt:** Where certain volumes of asphalt are prescribed the volume of asphalt measured at a temperature of 77° F. is anticipated, and computations of quantities will be so based. The coefficient of expansion is herein fixed at .0003 per degree F., and the following formula will be used in computing volumes applied:

$$V = \frac{V'}{K\,(t'-t) + 1}$$

where K = coefficient of expansion, V′ = volume of hot asphalt, t′ = temperature of hot asphalt, and t = normal temperature or 77° F. Or

$$V' = V\,[K\,(t'-t) + 1]$$

9.03. **Scope of Payment:** The Contractor shall accept the compensation, as herein provided, in full payment for furnishing all materials, labor, tools and equipment necessary to the completed work and for performing all work contemplated and embraced under the Contract; also for all loss or damage arising from the nature of the work, or from the action of the elements or from any unforseen difficulties which may be encountered during the prosecution of the work until its final acceptance by the Engineer, and for all risks of every description connected with the prosecution of the work; also for all expenses incurred in consequence of the suspension or discontinuance of the work as herein specified, and for any infringement of patent, trade mark, or copyright, and for completing the work according to the Plans and Specifications. The payment of any current or final estimate or of any retained percentage shall in no way affect the obligation of the Contractor, at his own cost, to repair or renew any defective parts of the construction or to replace any defective materials used in the construction under contract and to be responsible for all damage due to such defects, if such defects or damages are discovered on or before the final inspection and acceptance of the work. No monies payable under the Contract, except the estimate for the first month or period, shall become due if the Engineer so elects, until the Contractor shall satisfy the Engineer that he has fully settled for materials and equipment used in or upon the work and labor done in connection therewith.

9.04. **Payment and Compensation for Altered Quantities:** When alterations in plans or quantities of work as hereinbefore provided are ordered and performed and when such alterations result in increase or decrease of the quantity of work to be performed, the Contractor shall accept payment in full at the contract unit price for the actual quantities of work done and no allowance will be made for anticipated profits.

9.05. **Extra and Force Account Work:** Extra Work ordered and accepted shall be paid for under a "Supplemental Agreement" or as Force Account as agreed upon, as herein provided. In all cases such agreements shall be made before the work is started. When alterations in the plans or the work are productive of increased unit cost or decreased unit cost to the Contractor, a fair and equitable sum to be fixed and shown in a "Supplemental Agreement" signed by both Contracting Parties before such work is started, shall be added to or deducted from the Contract unit price as the case may be. When the Engineer deems it impracticable to handle any Extra Work ordered on the unit price basis a Supplement Agreement may be made up in any practical form desired, or the work may be ordered done and paid for on a Force Account basis as follows:

(a) For all labor, teams, and foreman in direct charge of the specific operation, the Contractor shall receive the current local rate of wage and the cost of the employers' liability insurance, to be agreed upon in writing before starting the work, to which shall be added an amount equal to fifteen (15) per cent of the sum thereof. No allowance shall be made for general superintendence and the use of small tools and ordinary equipment.

(b) For all materials used the Contractor shall receive the actual cost of such materials including transportation charges, as shown by original receipted bills, to which cost shall be added a sum equal to ten (10) per cent thereof.

(c) For any machine-power tools or special equipment, including pertinent fuel and lubricants, which it may be deemed necessary or desirable to use, the Engineer shall allow the Contractor a resonable rental price to be agreed upon in writing before such work is begun for the time that such tools or equipment are in use on the work and to which sum no percentage shall be added.

The compensation as herein provided shall be received by the Contractor as payment for "Extra Work" done on a "Force Account" basis. The Contractor shall make no claim for "Force Account" work unless performed on written order and in accordance therewith. The Contractor's representative and the Inspector shall compare records of extra work done on a force account basis at the end of each day. Copies of these records shall be made upon suitable forms provided for this purpose, and signed by both the Inspector and the Contractor's representative, one (1) copy being forwarded to the Engineer and one (1) to the Contractor. All claims for extra work done on a "Force Account" basis shall be submitted to the Engineer by the Contractor upon certified statements to which shall be attached original receipted bills covering the cost of and the transportation charges on all materials used in such work, and said statements shall be filed not later than the 10th day of the month following that in which the work was actually performed.

9.06. **Partial Payments:** The Engineer will make current estimates in writing once each month, provided the work is progressing satisfactorily, of the materials in place complete and the amount of work performed in accordance with the Contract, during the preceding month or period, and of the value thereof at the unit prices contracted. From the total of the amounts so ascertained will be deducted ten (10 per centum thereof to be retained by the Board until after the completion of the entire work or section thereof, as indicated in the plans and Special Provisions, in an acceptable manner; and the balance, or a sum approximating ninety (90) per centum there of, shall be certified and paid to the Contractor, except when such balance amounts to less than seven hundred and fifty dollars ($750.00). If at the close of the construction season for any year the Engineer shall find that this Contract is completed, except for burning the brush or other minor operations incident to finishing up the work, and that it is impracticable by reason of adverse weather conditions, or for other causes equally good for the Contractor to perform such burning or other finishing work before the beginning of the succeeding construction season, payment of the balance of the contract price may be made to the Contractor, less such amount as may be estimated by the Engineer to be sufficient to cover the cost of finishing such uncompleted work: Provided, however, that such payment shall not be made unless written request therefor shall be made by the Contractor with the consent of his Surety, and approved by the Engineer.

9.07. **Acceptance and Final Payment:** Whenever the work provided for by the Contract shall have been completely performed on the part of the Contractor, and all parts of the work have been approved by the Engineer and the Final Inspection made, a final estimate showing the value of the work done will be prepared by the Engineer as soon as the necessary measurements may be made. The amount of this estimate, less any sums that may have been deducted in accordance with the provisions of the Contract, and less all previous payments, will be paid jointly to the Contractor and the Surety Company within thirty (30) days after the final estimate has been approved by the Engineer.

PAMPHLET "E"

GEORGIA STATE HIGHWAY DEPARTMENT

STANDARD SPECIFICATIONS

1928

DIVISION II

CONSTRUCTION DETAILS

PAVEMENTS

AND

SURFACE COURSES

SECTION 45

SURFACE TREATMENT

45.01. **Description:** This item shall consist of a wearing surface composed of a single, double or triple application of bituminous materials and layers of stone or slag placed upon the prepared base course in accordance with these specifications and in conformity with the lines, grades and typical section shown on the plans. When required by special provisions or shown on the plans a prime coat shall be applied.

MATERIALS

45.02. **Stone or Slag:** The stone or slag shall consist of angular fragments of clean, hard, durable material of uniform quality throughout, free from disintegrated material, dirt, or other objectionable matter and well graded between the sizes specified.

a. **For first course of heavy treatment:**
Passing a 1½ inch screen not less than 100%
Retained on a ¾ inch screen not less than 96%

b. **For second course of heavy and medium and for light treatment:**
Passing a ¾ inch screen not less than 100%
Retained on a ¼ inch screen not less than 96%

c. **For first course of medium treatment:**
Passing a 1½ inch screen not less than 100%
Retained on a ¾ inch screen not less than 96%

d. **For third course of heavy and medium treatment:**
Passing a 5-8 inch screen not less than 100%
Retained on a 10 mesh sieve not less than 96%

45.03 **Petroleum Asphalt:** All petroleum asphalt shall be homogeneous free from water and shall not foam when heated to 347 degrees F.

It shall meet the following requirements as designated for its various uses.

(1) **Prime Coat Surface Treatment**
(a) Specific gravity at 77 degrees F., 0.935 to 0.970.
(b) Flash point, not over 122 degrees F.
(c) Less at 325 degrees F., 5 hrs., Max. 30%.
(d) Viscosity at 77 degrees F., 80 to 120.
(e) Total bitumen soluble in CS^2, at least 99.5%.

(2) **Heavy and Medium Surface Treatment**
(a) Specific gravity at 77 degrees F., 1.000.
(b) Flash point, at least 400 degrees F.
(c) Melting point, 95 degrees to 130 degrees F.
(d) Penetration at 77 degrees F., 100 grms., 5 sec., 100 to 120.
(e) Loss at 325 degrees F., 5 hrs., Max. 1.0 per cent.
(f) Penetration residue at 77 degrees F., 100 grms., 5 sec., at least 60.
(g) Total bitumen soluble in CS^2, at least 99.5%.
(h) Organic matter insoluble in CS^2, not over 0.20 per cent.
(i) Ductility at 77 degrees F., at least 30 C. M.

(3) **Light Surface Treatment**
The asphalt shall not foam when heated to 248° F.
(a) Specific gravity at 77° F. not less than 1,000
(b) Flash point not less than .... 400° F.
(c) Melting point (ring and ball) not less than .... 90° F.
(d) Penetration at 77° F. 100 grms. 5 sec. .... 200 to 230
(e) Loss at 325° F., 5 hrs. not over 1.50%
(f) Penetration of residue not less than 150
(g) Total bitumen soluble in CS_2 not less than 99.5%

45.04. Prime Coat, Refined Tar: Cold Application. Refined tar shall be homogeneous and shall not contain more than 2.0% of water by volume. It shall meet the following requirements:

(a) Specific gravity at 77° F. not less than	1.100
(b) Specific viscosity, Engler 50 CC. at 104° F.	8 to 13
(c) Total distillate by weight of water free oil	
at from 32° F. to 338° F., not over	5.0%
at from 32° F. to 455° F., not over	20.0%
at from 32° F. to 518° F., not over	30.0%
at from 32° F. to 572° F., not over	40.0%
Residue at 572° F., not less than	60.0%
(d) Total bitumen soluble in CS_2 not less than	90.0%

Tests of physical and chemical properties of all bituminous and other materials shall be made in accordance with requirements set forth in U. S. Department of Agriculture Bulletin No. 1216 of May 1924 and subsequent revisions.

CONSTRUCTION METHODS

45.05. Preparing Road Surfaces: (a) Bases of gravel, chert or semi-gravel, which are to be reshaped, shall be scarified to a depth of four (4) inches and the entire surface shall be reshaped, rolled, and wet down when necessary, until the surface is true to cross-section and grade, and has been thoroughly compacted. If additional materials are to be added to the base this material shall be added immediately after scarifying before reshaping begins. Ruts, pot holes, and other depressions shall be cleaned out and lightly scarified or otherwise loosened up to sufficient depth to insure bonding of new materials, which shall be placed and rolled in such manner as to bring the entire surface of the roadway to true grade and cross-section. Patching materials should be the same as that with which the road was built or material approved by the Engineer. All patches shall be thoroughly wetted and rolled, and this work shall be carried on far enough in advance of the surface treatment to insure the drying out of all patches before application of asphalt.

(b) When the surface of the roadway has been brought to the required grade and cross-section in the above manner, it shall be thoroughly swept with a power broom, care being taken to remove all dirt and clay or other objectionable material until the surface of the upper aggregate is exposed but the aggregate not loosened. If deemed necessary, the Engineer shall require the surface to be swept with hand brooms to insure clean surface.

(c) When shown on the plans or called for by the Special Provisions, the edges of the surface treatment shall be thickened. This extra thickness at the edges shall be four (4) inches in depth, in addition to the usual thickness of the surface treatment, unless otherwise specified, and shall be provided by digging a trench along each side of the pavement of the cross-section shown on the plan or called for in the special provisions. The trench shall be filled with the coarse paving aggregate and rolled with a heavy solid tire truck wheel or other satisfactory roller. After rolling, the aggregate in the trenches shall be penetrated with bituminous material conforming to these specifications sprayed by hand nozzels; sufficient bituminous material shall be applied to thoroughly coat and bond the aggregate and as may be directed by the Engineer.

The materials removed in excavation of the trench shall be placed on the shoulders and shaped as directed by the Engineer. The cost of placing and shaping this material shall be included in the unit price for digging the side trenches.

45.06 Prime Coat: When specified, after sweeping the surface a prime coat of from two-tenths (0.2) to three-tenths (0.3) of a gallon of priming material per square yard shall be applied in accordance with the methods provided in the Specifications for application of asphalt.

Priming material of tar shall always be applied to a limerock base.

After application of the priming material the surface of the road shall be covered with sand if necessary to prevent "picking up" and the road shall be opened to traffic. Sufficient time shall be allowed for the priming material to penetrate the surface and to cure properly before further work is undertaken. The time required for curing the prime coat will vary with weather conditions and conditions of the surface. (Thirty days generally required for curing prime coat on limerock base.)

After the prime coat has properly cured any excess of sand (and cakes of sand and priming material on limerock bases) shall be removed and the surface shall be swept clean before application of further bituminous material.

45.07. **Application of Bituminous Material:** No bituminous material shall be applied unless the base is thoroughly dry and the air temperature in the shade is not less than fifty (50°) degrees F. All bituminous material except prime coat shall be applied at a temperature of from three hundred and twenty-five (325) degrees to three hundred seventy-five (375) degrees F., by an approved type of self-propelled pressure distributor, operating under a pressure of not less than fifty (50) pounds. The bituminous ma-tuminous material shall be applied at a uniform rate, the amount per square yard shall be as follows:

(a) **Heavy Treatment:** First application 1.2 gallons per square yard.
Second application 0.3 gallons per square yard.

(b) **Medium Treatment:** First application 0.9 gallons per square yard.
Second application 0.3 gallons per square yard.

(c) **Light Treatment:** First application 0.4 gallons per square yard.

45.08. **Construction Methods:** The quantities of materials required by the Specifications are for average conditions. These quantities may be increased or decreased when, in the opinion of the Engineer, the condition of the base makes a change advisable. If the work is being paid for by the square yard extra compensation will be allowed for an increase in the total quantity above the specified quantities when so ordered.

45.09. **Heavy Treatment:** After the road surface and side trenches, if required, have been prepared the surface shall be uniformly covered with a layer of aggregate conforming to the requirements of Paragraph 45.02 (a) (size 1½" to ¾") from 1.4 to 1.5 cu. ft. of aggregate per square yard shall be used. The entire surface shall then be rolled with a self propelled three (3) wheel roller weighing not less than ten (10) tons nor more than twelve (12) tons. As soon as the rolling has been completed the first application of bituminous material shall be made and the surface shall be immediately covered with a uniform layer of aggregate conforming to the requirements of Paragraph 45.02 (b) (size ¾") to ¼"). From 0.3 to 0.35 cu. ft. of aggregate per sq. yd. shall be used. The entire surface shall then be rolled as heretofore specified and depressions shall be corrected. As soon as the rolling has been completed and the surface is uniform and true, the second application of bituminous material shall be made and the surface shall be immediately covered with a uniform layer of aggregate conforming to requirements of Paragraph 45.02 (d) (size 5/8" to 10 mesh). From 0.2 to 0.25 cu. ft. of aggregate per sq. yd. shall be used.

The entire surface shall then be rolled until it has been thoroughly compacted and is uniform and true.

Total materials required 1.5 gallons asphalt and 2.0 cu. ft. of aggregate per sq. yd.

45.10. (b) **Medium Treatment:** After the road surface and side trenches, if required, have been prepared and primed, if required, the surface shall be covered with a uniform layer of aggregate conforming to the requirements of Paragraph 45.02 (c) (size 1½" to ¾"). From 0.80 to 0.85 cu. ft. of aggregate per sq. yd. shall be used. The entire surface shall then be rolled with a self-propelled roller weighing not less than seven (7) tons nor more than ten (10) tons. After the rolling has been completed all low places and depressions shall be corrected and rerolled. The first application of bituminous material shall be made and the surface shall be immediately covered with a uniform layer of aggregate conforming to requirements of Paragraph 45.02 (b) (size ¾" to ¼"). From 0.30 to 0.4 cu. ft. of aggregate per sq. yd. shall be used. The entire surface shall then be rolled until it has been thoroughly compacted and is uniform and true. The second application of bituminous material shall be made and the surface shall be immediately covered with a uniform layer of aggregate conforming to requirements of Paragraph 45.02 (d) (size 5/8" to 10 mesh). From 0.2 to 0.25 cu. ft. of aggregate per square yard shall be used. The entire surface shall then be rolled until it has been thoroughly compacted and is uniform and true.

Total materials required 1.2 gallons asphalt and 1.4 cu. ft. of aggregate per sq. yds.

45.11. (c) **Light Treatment:** After the road surface has been prepared, and primed, if required, the bituminous material shall be applied and the surface shall be immediately covered with a uniform layer of aggregate conforming to requirements of Paragraph 45.02 (b) (size ¾" to ¼"). From 0.45 to 0.50 cu. ft. of aggregate per sq. yd. shall be used. The entire surface shall then be rolled until it has been thoroughly compacted and conforms to the grade and cross-section shown on the plans.

BASIS OF PAYMENT:

45.12. **Alternate No. 1.**

(a) **Preparing Road Surface:** This item will be paid for at the contract price per mile for "Preparing Road Surface," which price will be full compensation for furnishing all labor, materials and equipment necessary to complete this item. This item shall not include digging trenches for thickened edges. When extra material is to be added to the base, this material will be paid for at the contract unit price per cubic yard for "Additional Base Material", which price will be compensation in full for furnishing, hauling, placing and shaping.

(b) **Digging and Preparing the Trench:** This item will be paid for at the contract unit price per lin. ft. for "Side Trenches", which price will be full compensation for furnishing all labor, and equipment necessary to dig and shape the side trenches and to place material excavated on the shoulders and shape it as directed by the Engineer.

(c) **Aggregate:** This item will be paid for at the contract unit price per cu. yd. for "Aggregate," which price will be full compensation for furnishing all labor, materials, and equipment necessary in handling, placing and rolling the aggregates.

(d) **Bituminous Material:** This item will be paid for at the contract unit price per gallon for "Bituminous Material," which price will be full compensation for furnishing all labor, materials, and equipment necessary in handling, heating and applying the bituminous material. The unit quantity of this material paid for shall be one (1) gallon at seventy-seven (77°) degrees F.

45.13. **Alternate No. 2**

When so stated in the proposal "Surface Treatment" may be let at a unit price per square yard. If the work is let in this way the unit price per square yard for "Surface Treatment" will be compensation in full for furnishing all materials, equipment, labor and other things, necessary for preparing the road surface, sweeping, applying materials, rolling and completing the work in accordance with these specifications. If extra material is ordered placed by the Engineer, this material will be paid for at the agreed unit price per gallon for extra asphalt and per ton for extra aggregate.

Payment will be made under

Item No. 40, Preparing Road Surface (per mile).
Item No. 41, Side Trenches (per linear foot).
Item No. 42, Aggregate (cubic yard).
Item No. 42-A, Additional Base Material.
Item No. 43, Bituminous Material (per gallon).
Item No. 44, Light Surface Treatment (square yard).
Item No. 45, Medium Surface Treatment (square yard).
Item No. 46, Heavy Surface Treatment (square yard).

SECTION 46

BITUMINUS MACADAM SURFACE COURSE

(Penetration Method)

46.01. **Description:** This item shall consist of a surface course composed of coarse broken stone, or slag and bituminous binder, with a bituminous seal coat and stone chip covering, and shall be constructed in accordance with these specifications and in conformity with the lines, grades, compacted thickness, and typical cross-section shown on the plans.

MATERIALS

46.02. **Broken Stone:** The broken stone shall consist of angular fragments of rock, excluding shist, shale and slate, of uniform quality throughout, free from thin or elongated pieces, and of disintegrated stone, dirt or other matter occuring either free or as a coating on the stone. The stone shall have a French coefficient of wear not less than eight (8) and shall show itself satisfactory under rolling.

46.03. **Slag:** Broken slag aggregate shall consist of clean, tough, durable pieces of copper or iron furnace slag, reasonably uniform in density and quality, non-glassy and free from thin or elongated pieces, or any deleterious substance. The dry slag when shaken to refusal shall have a weight per cubic foot of not less than seventy-five (75) pounds, and a French coefficient of wear of not less than five and five tenths (5.5).

46.04. **Grading:** The broken stone or slag aggregate shall be uniformly graded and shall consist of that portion of the product of the crusher which, when tested by means of laboratory screens, will meet the requirements following:

Passing 2½ inch screen not less than	95%
Total passing 1½ inch screen	15 to 45%
Retained on 1 inch screen not less than	95%

46.05. **Stone Chips:** Stone chips shall conform to the quality requirements above except that it shall be of the following sizes; keying stone for filling the surface voids in the coarse stone shall pass one (1) inch circular opening and be retained on one-quarter (¼) inch, and for wearing course shall pass five-eighths (5-8) inch screen and be retained on a No. 10 Sieve. Material for seal course shall pass a one-quarter (¼) inch screen and shall not contain an appreciable amount of dust. In all cases the stone shall be graduated uniformly from coarse to fine.

46.06. **Petroleum Asphalt:** All petroleum asphalt shall be homogeneous free from water and shall not foam when heated to 347° F. It shall meet the following requirements:

(a) Specific gravity at 77° F., not less than 1.000.
(b) Flash point, at least 347° F.
(c) Melting point, 104° to 140° F.
(d) Penetration at 77° F., 100 grms., 5 sec., 85 to 100.
(e) Loss at 325° F., 5 hrs., maximum 1.0%.
(f) Penetration residue at 77° F., 100 grms., 5 sec., at least 50.
(g) Total bitumen soluble in CS_2, at least 99.5%.
(h) Organic matter insoluble in CS_2, not over 0.20%.

46.07. **Refined Tar:** Refined tar shall be homogeneous and free from water. It shall meet the following requirements:

(a) Specific gravity at 77 degrees, 1.150 to 1.200.
(b) Float test at 122 degrees F., 150 to 180 seconds.
(c) Distillate by weight to 338 degrees F., not over 1.0%.
(d) Distillate by weight to 518 degrees F., not over 10.0%.
(e) Distillate by weight to 572 degrees F., not over 20.0%.
Melting point of residue not more than 149° F.
Total bitumen soluble in CS^2, 97 to 100%.

46.08. **Fluxed Bermudez Asphalt:** Fluxed native asphalt shall be homogeneous, free from water and shall not foam when heated to three hundred and forty-seven degrees (347°) F. It shall meet the following requirements:

(a) Specific gravity at 77 degrees F., 1.055 to 1.075.
(b) Flash point, at least 347 degrees F.
(c) Melting point, 104 degrees to 122 degrees F.
(d) Penetration at 77 degrees F., 100 grms., 5 sec., 85 to 100.
(e) Loss at 325 degrees F., 5 hrs., not over 3.0%.
(f) Penetration of the residue at 77 degrees F., 100 grms., 5 sec., at least 45.
(g) Total bitumen soluble in CS^2, at least 95.0%.
(h) Inorganic matter insoluble in CS^2, not over 3.0%.

Tests of all bituminous and other materials shall be made in accordance with the requirements set forth in U. S. Department of Agriculture Bulletin No. 1216 of May 1924 and subsequent revisions.

CONSTRUCTION METHODS

46.09. **Forms:** Rolling boards three (3) inches thick and of a minimum width of eight (8) inches shall be carefully laid to line and grade and shall be so held in place by stakes or other approved means, that the rolling operation will not disturb their alignment or grade.

46.10. **Spreading and Compacting Coarse Aggregate:** The prepared base shall be cleared of all foreign substances and the coarse aggregate spread upon it with shovels from piles along the side of the roadway or from a dumping board or by spreading devices approved by the Engineer. This aggregate shall be spread to a uniform depth to secure the compacted thickness shown on the plans. It shall then be rolled to bring it to a stable uniform surface true to line and grade and the typical section shown on the plans, with an approved type of ten (10) ton three wheel roller. Any depressions or irregularities that may develop shall be corrected by the addition of material where necessary.

46.11. **Application of Bituminous Binder:** No bituminous binder shall be applied unless the entire depth of the surface course is thoroughly dry and the air temperature in the shade is not less than fifty (50) degrees F., unless by written permission of the Engineer.

Any of the surface coarse material that has been coated or mixed with dirt and foreign substance shall be removed and replaced with clean stone.

After the coarse stone has been spread and compacted as above specified, there shall be applied to the surface one and sixty-five one hundredths (1.65) to one and three-quarters (1¾) gallons, as directed, of the Bituminous binder to each square yard of the surface area. The Bituminous binder shall be heated to and applied at a temperature of not less than three hundred and twenty-five (325) degrees F., not more than three hundred and seventy-five (375) degrees F., if an asphalt, (and not less than one hundred and seventy-five (175) degrees F., nor more than two hundred and seventy-five (275) degrees F., if a tar product), as may be directed by the Engineer.

The contrcator shall furnish and keep an accurate thermometer at the heating plant and on the distributor at all times.

46.12. Bituminous binder shall be uniformly spread over the surface by approved pressure distributors operating under an even pressure of not less than fifty (50) pounds per square inch, in such manner as not to disturb the stone or screenings, and to leave the surface true and uniform without depressions or irregularities.

46.13. If, after the application of the Bituminous binder, it appears that the material was applied upon ruts or other depressions caused by the wheels of the distributor passing over the surface of the stone in advance of the application of the binder, the same shall be restored and rebuilt at the expense of the Contractor applying the Biuminous binder.

46.14. In order to insure uniformity at junctions of two applications, when the last of the applications starts to thin, the distributor shall be shut off and upon starting the next application building paper shall be spread over the latter part of the previous application and the distributor shall lap back over this paper sufficiently to start the sprayers full force when uncovered stone surface is reached. This building paper shall then be removed and destroyed.

46.15. **Spreading Key Stone:** After the Bituminous binder has been applied and while it is still warm, a layer of keying stone shall be spread in such quantity as will just fill the surface voids and cover the entire surface of the coarse stone. Rolling shall then be continued until the material is compacted and the surface is bonded thoroughly. After the surface has been compacted as above, it shall be swept clean of all loose stone.

46.16. **Application of Wearing Course:** There shall then be applied to the surface, five-tenths (5/10) to seven-tenths (7/10) gallons of Bituminous binder per square yard of surface area.

46.17. **Spreading and Compacting Wearing Course:** Immediately after applying the Bituminous binder and while it is still warm it shall be covered with sufficient stone chips, five-eighths (5/8) inch to one-fourth (1/4) inch, to cover all exposed binder. Rolling shall then be continued until the surface has bonded thoroughly. Where required additional aggregate shall be applied to take up all excess Bituminous material.

46.18. **Application of Seal Coat:** At a time directed by the Engineer, all dirt and material which would prevent the Bituminous binder from adhering, shall be swept from the surface and from four-tenths (4/10) to five-tenths (5/10) gallons of Bituminous binder shall be applied to each square yard of surface area. This shall be immediately covered with fine aggregate from one-quarter (¼) inch down but free of dust in sufficient quantity to take up all excess bitumen. The surface shall then be rolled as directed. Traffic may then be turned on.

46.19. **Testing Surface:** The finished surface shall show no deviation from the general surface in excess of five sixteenths (5-16″) of an inch in a distance of ten feet measured in the following manner. A ten (10) foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depressions immediately after the final rolling and ordinates measured from the bottom of the straight edge to the surface of the pavement shall not exceed five sixteenths (5-16″) of an inch at any point. Such portions of the completed pavement as are defective in finish, compression density or composition or that do not comply in all respects with the requirements of these Specifications, shall be taken up, removed and replaced with suitable material properly laid in accordance with these Specifications.

BASIS OF PAYMENT

46.20. **Alternate No. 1.** (a) **Aggregate:** This item will be paid for at the contract unit price per square yard for "Aggregate" compacted in place, which price will be full compensation for furnishing all labor, materials, and equipment necessary in handling, placing and rolling the aggregate.

(b) **Bituminous Material:** This item will be paid for at the contract unit price per gallon for "Bituminous Material," which price will be full compensation for furnishing all labor, materials, and equipment necessary in handling, heating and applying the bituminous material. The unit of quantity of this material paid for shall be one gallon at seventy-seven (77) degrees Fahrenheit.

46.21. **Alternate No. 2:** When so stated in the proposal "Bituminous Macadam Surface Course" may be let at a unit price per square yard complete in place. If the work is let in this way the unit price per square yard for "Bituminous Macadam Surface Course" will be full compensation for furnishing, hauling and placing all materials, for all equipment, tools, labor and incidentals necessary to complete the item.

Payment will be made under
Item No. 47, Aggregate (square yard).
Item No. 48, Bituminous Material (per gallon).
Item No. 49, Bituminous Macadam Surface Course (square yard.)

SECTION 47

BITUMINOUS CONCRETE SURFACE COURSE (Modified Topeka)

47.01. **Description:** This item shall consist of a wearing course composed of a compacted mixture of mineral aggregate and bituminous material, and shall be constructed on the completed base course in accordance with these specifications and in conformity with the lines, grades, compacted thickness, and typical cross-section shown on the plans.

MATERIALS

47.02. **Sand:** The sand shall consist of sound clean, hard, durable grains and shall besograded that when tested with standard laboratory sieves it will meet the following requirements by weight:

Passing No. 10 sieve, retained on No. 40	10% to 40%
Passing No. 40 sieve, retained on No. 80	25% to 60%
Passing No. 80 sieve, retained on No. 200	16% to 45%
Passing No. 200 sieve	0% to 6%

These limits shall cover the natural variation in the sources of supply, but the Engineer reserves the right to vary the grading within the limits given as may be rendered necessary by the character of the traffic and other conditions in order to obtain a dense and stable mixture.

47.03. **Mineral Filler:** The filler for bitumous concrete wearing surface shall consist of Portland cement or approved dust prepared from crushed rock, all passing a standard No. 50 laboratory sieve and not less than sixty-seven (67) per cent of which shall pass a No. 200 sieve.

47.04. **Broken Stone:** The broken stone shall consist of angular fragments of rock, excluding shist, shale, and shate; free from thin, elongated pieces, sand, disintegrated stone, dirt or other objectionable matter occurring, either free or as a coating on the stone. Not less than ninety-five (95) per cent shall pass a laboratory screen with five-eighths (5/8) inch openings and not less than sixty (60) per cent shall be retained on a one-fourth (¼) inch screen. Samples of the stone when subjected to the hardness, toughness and abrasion tests, as described in the U. S. Department of Agriculture Bulletin No. 1216, shall show a hardness of not less than ten (10); toughness of not less than eight (8) and a French coefficient of wear not less than eight (8.)

47.05. **Slag:** Broken slag aggregate shall consist of clean, tough, durable pieces of copper or iron furnace slag, reasonably uniform in density and quality, non-glassy and free from thin or elongated pieces, or any deleterious substance. The dry slag when shaken to refusal shall have a weight per cubic foot of not less than seventy-five (75) pounds and a French coefficient of wear of not less than five and five tenths (5.5).

The grading shall conform to the requirements of Paragraph 47.04.

47.06. **Petroleum Asphalt:** Petroleum asphalt shall be homogeneous, free from water and shall not foam when heated to 347° F. It shall meet the following requirements:

(a) Specific gravity at 77 degrees F., at least 1.020.
(b) Flash point, at least 450 degrees F.
(c) Melting point, 113 to 149 degrees F.
(d) Penetration at 77 degrees F., 100 grms., 5 sec., 40 to 50.
(e) Loss at 325 degrees F., 5 hrs., Max. 1.0%.
(f) Penetration residue at 77 degrees F., 100 grms., 5 sec., at least 25.
(g) Total bitumen soluble in CS^2, at least 99.5%.
(h) Organic matter insoluble in CS^2, not over 0.20.
(i) Ductility at 77 degrees F., at least 30 C. M.

47.07. **Fluxed Bermudez Asphalt:** Fluxed native asphalt shall be homogeneous, free from water and shall not foam when heated to 347° F. It shall meet the following requirements:

(a) Specific gravity at 77 degrees F., 1.055 to 1.075.
(b) Flash point, at least 450 degrees F.
(c) Melting point, 113 degrees to 131 degrees F.

(d) Penetration at 77 degrees F., 100 grms., 5 sec., 40 to 50.
(e) Loss at 325 degrees F., 5 hrs., Max. 3.0%.
(f) Penetration residue at 77 degrees F., 100 grms, 5 sec., at least 20.
(g) Total bitumen soluble in CS^2, at least 94%.
(h) Organic matter insoluble in CS^2, 2.5% to 4.0%.
(i) Ductility at 77 degrees F., at least 30 C. M.

Tests of all bituminous and other materials shall be made in accordance with the requirements set forth in U. S. Department of Agriculture Bulletin No. 1216 of May 1924 and subsequent revisions.

CONSTRUCTION METHODS

Preparation of Mixture

47.03. **Heating Mineral Aggregate:** The broken stone or slag and sand for the Bituminous concrete shall be heated, as directed, before entering the mixer to between two hundred and seventy-five (275) degrees F. and three hundred and seventy-five (375) degrees F., in revolving dryers, in which no flame shall be permitted to come in contact with the broken stone or slag and sand, and in which the broken stone and sand shall be continuously agitated during the heating.

47.09. **Heating Bituminous Material:** The Bituminous material shall be heated in kettles so designed as to admit of even heating of the entire mass, with an efficient and positive control of the heat at all times. It shall be heated as directed to a temperature of between two hundred and fifty (250) degrees F., and three hundred and fifty (350) degrees F.

When refined asphalt is to be combined with a flux, the mixture shall be thoroughly agitated until a homogeneous cement of the required penetration is produced. The penetration of the asphaltic cement shall be tested at suitable intervals to insure that it is maintained at a uniform consistency throughout the period of use.

47.10. **Thermometers Furnished by Contractors:** The Contractor shall provide a sufficient number of accurate, efficient, stationary thermometers for determining the temperature of the Bituminous material in kettles. A registering pyrometer shall be installed at a suitable place at the discharge end of the dryer to clearly indicate the temperature of the aggregate when discharged.

47.11. **Mixing:** When thoroughly heated to the temperature directed, the Bituminous material and mineral aggregate for the Bituminous concrete shall be mixed so that the resulting mixture shall contain from seven (7) to nine and one-half (9½) per cent of bitumen by weight as directed. Percentage of bitumens shall not vary more than one-half (½) of one (1) per cent plus or minus from the amount in the formula approved by the Engineer.

47.12. **Total Mineral Aggregate:** The total mineral aggregate shall consist of a uniform mixture of broken stone, sand and mineral filler. The required grading of each being such as to produce, when properly proportioned, a mixture conforming to the following limitations for grading. The exact proportion of each constituent producing a total mineral aggregate within these limitations shall be as directed by the Engineer.

When tested by means of laboratory screens and sieves the total mineral aggregate shall meet the following requirements:

Passing	½ inch and retained on a ¼ inch screen	12% to 25%
Passing	¼ inch screen and retained on a 10 mesh sieve	10% to 20%
Passing 10	mesh sieve and retained on a 40 mesh sieve	7% to 25%
Passing 40	mesh sieve and retained on a 80 mesh sieve	11% to 36%
Passing 80	mesh sieve and retained on a 200 mesh sieve	10% to 25%
Passing 200	mesh sieve	5% to 11%

47.13. A mixer shall be used having revolving blades, and so designed and operated as to produce and discharge thoroughly coated and uniform mixture of non-segregated broken stone, sand and Bituminous material. When discharged the mixture shall have a temperature of not more than three hundred and fifty (350) degrees F. and not less than two hundred and fifty (250) degrees F., as directed.

47.14. **Surface Foundation:** All defective areas in the foundation shall be repaired as directed in advance of laying the Bituminous concrete. Before laying the Bituminous concrete the surface of the foundation shall be dry and thoroughly cleaned.

47.15. **Forms:** Rolling boards three (3) inches thick and of a minimum width of eight (8) inches shall be carefully laid to line and grade and shall be so held in place by stake or other approved means, that the rolling operation will not disturb their alignment or grade.

47.16. **Laying Bituminous Concrete:** The Bituminous concrete, heated and prepared as specified, shall be delivered direct from the mixer to the point of deposition on the foundation in trucks or wagons, provided with canvas for retaining the heat. As delivered, the Bituminous concrete shall have a temperature of at least two hundred and twenty-five (225) degrees F. Material having a lower temperature than this shall not be laid upon the foundation. Before the Bituminous concrete is placed, all contact surfaces of curbs, edgings, manholes, etc., shall be well painted with hot Bituminous material. The hot Bituminous material shall be dumped upon platforms, constructed as directed, and shoveled with hot shovels into position on the foundation. The Bituminous concrete shall be immediately spread as directed over the foundation course by men experienced in such work so that when compacted it shall have a thickness at no place less than two (2) inches, and shall be free from surface depression and irregularities.

47.17. **Rollers:** Two rollers shall be used. The initial compression of the surface course shall always be secured with a ten (10) to twelve (12) ton three wheel roller, but final compression shall always be secured with an eight (8) to ten (10) ton tamden roller. Each shall have a compression under the rear roller of between three hundred (300) and three hundred and sixty (360) pounds per linear inch of roll, and shall be provided with an ash pan, which shall prevent ashes from dropping upon the Bituminous concrete.

47.18. **Compacting:** The Bituminous concrete course, laid as specified, shall be rolled at once while the mixture is warm and pliable, beginning at the edges, and working toward the center. Means for preventing the Bituminous material from adhering to the roller shall be provided as directed. Rolling shall be continued without interruption at a rate not to exceed two hundred (200) square yards per hour per roller until all roller marks are liminated and the surface mixture has a density of not less than 94% of the theoretical density. Places which the roller cannot effectively reach shall be tamped thoroughly with hot tampers.

47.19. **Joints:** Placing the surface course shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is discontinued for such length of time as to permit the mixture to become chilled. In all such cases when the work is resumed, the material laid shall be cut back so as to produce a slightly beveled edge for the full thickness of the course. The old material which has been cut away shall be removed from the work and new mix laid against the fresh cut. If desired a stout rope may be stretched across the pavement where the joint is to be made. When the work is resumed, the material laid shall be cut back to the rope which will be removed together with the surplus material and the fresh mix laid against the joint thus formed. Hot smoothing irons may be used for sealing joints, but in such case, extreme care shall be exercised to avoid burning the surface.

47.20. Such portions of the completed pavement as are defective in finish, compression, density, or composition, or that do not comply in all respects with the requirements of the Specifications, shall be taken up, removed, and replaced with suitable material properly laid in accordance with these Specifications.

47.21. **Testing Surface:** The surface of the pavement after compression shall be smooth and true to the established crown and grade. Immediately after initial compression the surface shall be tested for conformity with the established crown and grade and by application of a ten (10) foot straight edge parallel to the center line of the roadway as described elsewhere in this paragraph and any defective places thus disclosed shall be immediately remedied by removing the surface course mixture at such spots, and replacing it with hot fresh surface course mixture which shall be immediately compacted to conform with the surrounding area.

The finished pavement surface shall show no deviation from the general surface in excess of one-sixteenth (1/16) inch per foot, as measured in the following manner: a ten (10) foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depressions and ordinates measured from the face of the straight edge to the surface of the pavement shall not exceed one-sixteenth (1/16) inch for each foot in distance from nearest point of contact.

47.22. **Seasonal and Weather Limitations:** No bituminous concrete shall be mixed or placed between December 1st and April 1st, except by written permission, and no bituminous concrete shall be mixed or placed when the air temperature in the shade is below fifty (50) degrees F., or when the foundation is damp or otherwise unsatisfactory.

The Contractor shall provide at the mixing plant, a suitable place for the plant Inspector to conduct the necessary tests, and to safely keep the necessary laboratory equipment. Until this provision is made the Inspector may suspend operations.

47.23. **Basis of Payment:** This item will be paid for at the contract unit price per square yard for "Bituminous Concrete" (Modified Topeka Type), complete in place, which price will be full compensation for furnishing, hauling and placing all materials, for all equipment, tools, labor and incidentals necessary to complete the item.

Payment will be made under
Item No. 50, Bituminous Concrete (Modified Topeka) (square yard).

SECTION 48

BITUMINOUS CONCRETE SURFACE COURSE (Coarse Aggregate Type)

48.01. **Description:** This item shall consist of a bituminous concrete surface course constructed in one layer on the prepared base course in accordance with these specifications and in conformity with the lines, grades, and typical cross section shown on the plans. The bituminous concrete shall consist of a mineral aggregate composed of stone or slag, sand and mineral filler, uniformly mixed with asphaltic cement and shall be spread on the prepared base to such a depth that after compaction it shall have the thickness shown on the plans.

MATERIALS

48.02. **Coarse Aggregate:** The coarse aggregate shall consist of broken stone or slag.

48.03. **Stone:** The broken stone shall be of sound, hard, tough, and uniform quality and shall be free from dust, dirt or other deleterious matter occurring either free or as a coating on the stone and an excess of thin or elongated pieces. It shall have a coefficient of wear of not less than seven (7).

48.04. **Slag:** The broken slag shall consist of clean, tough, durable pieces of copper or iron furnace slag reasonably uniform in density and equality, non-glassy and free from thin or laminated pieces or any deleterious matter. It shall contain not more than one and five-tenths (1.5) per cent of sulphur and the dry slag when shaken to refusal shall have a weight per cubic foot of not less than seventy-five (75) pounds. Slag shall have a coefficient of wear of not less than five and five-tenths (5.5).

48.05. **Grading:** When tested by means of laboratory screens, the coarse aggregate, shall meet the following requirements:

Passing 1¼ inch screen, not less than 95 per cent.
Passing ¾ inch screen, 25 to 75 per cent.
Passing ¼ inch screen, 0 per cent.

Any material which passes the ¼ inch screen shall in laboratory tests, for the purpose of proportioning the paving mixture, be considered as fine aggregate.

48.06. **Fine Aggregate:** The fine aggregate for suface course mixture shall consist of sand composed of clean, hard, durable grains, free from clay, loam, and other foreign matter, together with particles which pass a one-quarter (¼) inch laboratory screen which may be present in the coarse material. When tested by means of laboratory screens and sieves, the sand, or total fine aggregate, shall meet the following requirements:

Passing	Retained on	Per Cent
¼ inch screen		100
¼ inch screen	10 mesh sieve	0 to 20
10 mesh sieve	40 mesh sieve	15 to 50
40 mesh sieve	80 mesh sieve	25 to 65
80 mesh sieve	200 mesh sieve	7 to 40
200 mesh sieve		0 to 6

48.07. **Mineral Filler:** The mineral filler shall consist of thoroughly dry limestone dust, slate dust, Portland cement, or other material approved in writing by the Engineer, which when tested by means of laboratory sieves shall meet the following requirements:

Passing 30 mesh sieve, 100 per cent.
Passing 200 mesh sieve not less than 65 per cent.

48.08. **Intermediate Aggregate:** The intermediate aggregate for seal coat shall consist of broken stone. It shall be of reasonably uniform quality and shall be free from dust. When tested by means of laboratory screens it shall meet the following requirements.

Passing ½ inch screen, not less than 95 per cent.
Passing ¼ inch screen, 25-40 per cent.
Passing 10 mesh sieve, 0-5 per cent.

48.09. **Fluxed Bermudez Asphalt:** The fluxed native asphalt shall be homogeneous, free from water, and shall not foam when heated 347° F.

It shall meet the following requirements:

(a) Specific gravity at 77 degrees F., 1.055 to 1.075.
(b) Flash point, not less than 347 degrees F.
(c) Melting point, 113 degrees F. to 131 degrees F.
(d) Penetration at 77 degrees F., 100 grms., 5 sec., 40 to 50.
(e) Loss at 325 degrees F., 5 hrs., not more than 3.0%.
(f) Penetration of residue at 77 degrees F., 100 grms., 5 sec., not less than 20.
(g) Total bitumen (soluble in carbon disulphide) not less than 94.0%.
(h) Inorganic matter insoluble 2.5% to 4.0%.

48.10. **Petroleum Asphalt:** The petroleum asphalt shall be homogeneous, free from water, and shall not foam when heated 347 degrees F.

It shall meet the following requirements:

(a) Specific gravity, 77 degrees F., not less than 1.020.
(b) Flash point, not less than 347 degrees F.
(c) Melting point, 113 degrees F., 149 degrees F.
(d) Penetration at 77 degrees F., 100 grms., 5 sec., 40 to 50.
(e) Loss at 325 degrees F., 5 hrs., not more than 1.0%.
(f) Penetration of residue at 77 degrees F., 100 grms., 5 sec., not less than 25.
(g) Total bitumen (soluble in carbon disulphide) not less than 99.5%.
(h) Organic matter insoluble, not more than 0.2%.

48.11. **Fluxed Trinidad Asphalt:** The fluxed native asphalt shall be homogeneous, free from water, and shall not foam when heated to 347 degrees F.

It shall meet the following requirements:

(a) Specific gravity, 77 degrees, 1.210 to 1.270.
(b) Flash point, not less than 347 degrees F.
(c) Melting point, 122 degrees F. to 140 degrees F.
(d) Penetration at 77 degrees F., 100 grms., 5 secs., 40 to 50.
(e) Loss at 325 degrees F., 5 hrs., not more than 3.0%.
(f) Penetration of residue at 77 degrees F., 100 grms., 5 secs., not less than 20.
(g) Total bitumen (soluble in carbon disulphide) not less than 65.0%.
(h) Inorganic matter insoluble, 22.0% to 32.0%.

Note: Material for any one contract shall not vary more than 0.020 in specific gravity nor more than 10 degrees C. in melting point within the test limits above specified.

CONSTRUCTION METHODS

48.12. **Preparation of Asphaltic Cement:** (a) The asphaltic cement shall be melted in kettles or tanks designed to secure uniform heating of the entire contents and shall be brought to a temperature of 250 degrees F. to 350 degrees F.

When refined asphalt is to be combined with a flux the mixture shall be thoroughly agitated until a homogeneous asphaltic cement of the required penetration is produced. The penetration of the asphaltic cement shall be tested at suitable intervals to insure that it is maintained at a uniform consistency throughout the period of use.

48.13. **Preparation of Mineral Aggregate:** (a) The coarse and fine aggregate for surface course mixture shall be dried and heated at the paving plant in suitably designed revolving driers. They shall be heated to a temperature of 225 degrees F. to 350 degrees F. as determined on the mixing platform. The aggregate may be simultaneously fed into the same drier, but in such case they shall immediately after heating be screened into coarse and fine aggregate and stored in separate bins, except in plants where the aggregates are proportioned and dried by the batch method. When more than two ingredients enter into the composition of the mineral aggregate they shall be combined in a manner satisfactory to the Engineer before entering the elevator.

(b) A registering pyrometer shall be installed at a suitable point at the discharge end of the drier with the registering device so located as to clearly indicate to the drum fireman the temperature of the mineral aggregate when discharged.

48.14. (a) The coarse and fine aggregate and mineral filler for surface course mixture shall be measured separately and accurately either by weight or volume for each batch to be mixed. The required quantity of hot asphaltic cement for each batch shall be measured by actual weighing with scales attached to the asphaltic cement bucket. The mixture shall be made in an approved twin pug mill or batch mixer by first charging it with coarse aggregate, fine aggregate and mineral filler. After these have been thoroughly mixed the asphaltic cement shall be added and the mixing continued for a period of at least forty-five (45) seconds or longer if necessary to produce a homogeneous mixture, in which all particles of the mineral aggregate are uniformly coated. The ingredients shall be heated and combined in such a manner as to produce a mixture which when discharged shall not vary more than 30 degrees F. from the temperature set by the Engineer. Any mixture varying more than 30 degrees F. shall be rejected. Every effort should be made to have the mixture leave the plant as near a constant temperature as possible.

(b) The constituents of the surface course mixture shall be combined to such proportions as to produce a mixture conforming to the following composition limits by weight:

Passing 1¼ inch, retained on ½ inch screen	30 to 60 per cent.
Passing ½ inch retained on ¼ inch screen	15 to 25 per cent.
Passing ¼ inch, retained on 10 mesh sieve	5 to 15 per cent.
Passing 10 mesh sieve, retained on 200 mesh sieve	20 to 35 per cent
Passing 200 mesh sieve	4 to 6 per cent.
Bitumen (soluble in carbon tetrachloride)	5 to 8 per cent.

The portion of the fine aggregate passing the 10 mesh shall meet the sand requirements under sheet asphalt pavement except that the grading requirements shall be as follows:

Passing 10 mesh and retained on a 40 mesh	15 to 40 per cent.
Passing 40 mesh and retained on an 80 mesh	22 to 53 per cent.
Passing 80 mesh and retained on a 200 mesh	15 to 40 per cent
Passing 200 mesh	10 to 15 per cent.

The proportions shall be verified within the limits designated, as directed by the Engineer. The percentage of bitumen, in the finished wearing surface shall not show a greater variation than one-half of one per cent, plus or minus, from the amount in the formula approved by the Engineer.

48.15. **Paving Plant Inspection:** For the verification of weights or proportions and character of materials, and determination of temperatures used in the preparation of the mixture the Engineer or his authorized representatives shall have access at any time to all parts of the paving plant.

48.16. **Transportation of Mixture:** The surface course mixture shall be transported from the paving plant to the work in tight vehicles previously cleaned of all foreign materials and when directed by the Engineer each load shall be covered with canvass or other suitable material of sufficient size and thickness to protect it from the weather conditions. No loads shall be sent out so late in the day as to interfere with spreading and compacting the mixture during daylight unless artificial light satisfactory to the Engineer is provided.

48.17. **Placing Surface Course Mixture:** Prior to the arrival of the surface course mixture on the work the prepared base shall be cleaned of all loose and foreign materials. The mixture shall be delivered at a temperature specified by the Engineer, and shall be between 225 degrees F. and 325 degrees F. It shall be laid only upon a base which is dry, or at least free from standing water, and only when weather conditions are suitable. No material shall be laid except by written permission of the Engineer when the air temperature in the shade is below 50 degrees F.

The Engineer may permit, however, work of this character to continue when overtaken by sudden rain, up to the amount which may be in transit from the plant at the time, provided the mixture is within temperature limits specified. Upon arrival on the work, the surface course mixture shall be dumped on approved steel dump boards outside of the area on which it is to be spread, and shall then be immediately distributed into place by means of hot shovels and spread with hot rakes in a uniformly loose layer of correct depth.

The depth of this layer shall be gauged at least every three (3) feet by means of a templet cut to proper crown and section of roadway as shown on sheet of standards, allowing sufficient depth for compression. Any deviation from standard crown and section as indicated by templet shall be immediately remedied by placing new or removing surplus material.

Straight edging and backpatching shall be done after initial compression has been secured and while material is still hot.

Contact surface of curbings, gutters, manholes, etc., shall be painted with a thin uniform coating of hot asphaltic cement or asphaltic cement dissolved in naptha, just before the surface mixture is placed against them. Immediately adjacent to headers, flush curbings, gutters, liners and other structures, the surface course mixture shall be spread uniformly high so that after compaction it will be one-quarter (¼) inch above the edges of such structures.

48.18. **Compacting Surface Course:** (a) Two rollers shall be used for securing compression. One shall be eight (8) to ten (10) ton tandem roller and the other shall be a ten (10) to twelve (12) ton three-wheel power roller. All rollers shall be kept in good condition and shall weigh not less than two hundred and fifty (250) pounds to the inch width of tread. Each roller shall be in charge of a competent, exprienced roller engineer, and must be kept in continuous operation as nearly as practicable. The ashes from the roller must not be dumped upon wearing surface course. Rolling shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive strips by at least one-half (½) the width of the roller. The pavement shall then be subjected to diagonal rolling in two directions, the second diagonal rolling crossing the lines of the first. If the width of the pavement permits, it shall in addition be rolled at right angles to the center line. Rolling shall be continued until all roller marks are eliminated and the surface mixture has a density of not less than ninety-four (94) per cent of the theoretical density. The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture and any displacement occurring as a result of reversing the direction of the roller, or from any other cause shall at once be corrected by the use of rakes and of fresh mixture when required. Rolling shall proceed at an average rate not to exceed two hundred (200) square yards per hours per roller, and shall continue until no further compression is possible. To prevent adhesion of the surface course mixture to the roller, the wheels shall be kept properly oiled, but excess oil will not be permitted.

(b) Along the curbs, headers and similar structures and all places not accessible to the roller, the surface course mixture shall be thoroughly compacted with hot tampers.

(c) The surface of the mixture after compression shall be smooth and true to the established crown and grade. Any mixture which becomes loose or broken, mixed with dirt or in any way defective prior to application of the seal coat, shall be removed and replaced with fresh hot surface course mixture, which shall be immediately compacted to conform with the surrounding area. The finished pavement surface shall show no deviation from the general surface in excess of one-sixteenth (1-16) inch per foot as measured in the following manner: a ten (10) foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depressions, and ordinates measured from the face of the straight edge to the surface of the pavement shall not exceed one-sixteenth (1/16) inch for each foot in distance from the nearest point of contact.

48.19. **Joints:** Placing of the surface course shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is to be discontinued for such length of time as to permit the mixture to become chilled. In all such cases, including the formation of the joints as hereinafter specified, provision shall be made for proper bond with new surface mixture by cutting or trimming back the joint while the material is hot so as to expose an unsealed or granular surface for the full specified depth of the course. At the end of each day's work on surface mixture, joints shall be formed by laying and rolling against boards of the thickness of the compacted mixture, placed across the entire width of the pavement or by such other method as may be approved by the Engineer. When the laying of the suface course mixture is resumed the exposed edge of the joint shall be painted with a thin coat of hot asphaltic cement or asphaltic cement thinned with naptha, and the fresh mixture shall be raked against the joint, thoroughly tamped with hot tampers and roller.

48.20. **Correction of Defective Surface:** Such portions of the completed pavement as are defective in surface finish, compression, density or composition, or that do not comply in all respects with the requirements of these Specifications, shall be taken up, removed and replaced with suitable material, properly laid in accordance with these Specifications.

48.21. **Seal Coat.** (a) **Flush Seal Coat:** After the pavement has been compacted as specified, and as soon as possible hot asphaltic cement of character herein specified, shall be uniformly squeegeed over the suface at the rate of from two-tenths (0.2) to four-tenths (0.4) gallons per square yard as directed by the Engineer. Asphaltic cement shall be applied only when the surface course mixture is thoroughly dry. Upon this seal coat shall be immediately spread sufficient quantity of aggregate described under "Intermediate Aggregate" to completely cover and take up any excess of bitumen. If necessary, this aggregate shall be heated before being spread. Rolling shall be continued until the resulting surface is thoroughly compressed.

(b) The asphaltic cement shall be heated in kettles or tanks brought to a temperature of 275 degrees F. as directed by the Engineer. The Contractor shall provide all necessary facilities for determining the temperature of the asphaltic cement during heating and prior to application.

(c) After the asphaltic cement has been squeegeed over the surface and while it is still warm, dry intermediate aggregate shall be broadcast over the surface and rolled until thoroughly bonded to the road. As required, additional intermediate aggregate shall be spread and broomed over the surface during rolling in sufficient quantity to take up all excess of asphaltic cement. Upon completion of the pavement, however, only a very light covering of loose intermediate aggregate shall be allowed to remain on the road.

48.22. **Protection of Pavement:** If at the time of laying surface course mixture permanent side supports such as curbs, edgings or gutters have not been constructed, planks of suitable thickness shall be laid along each side of the pavement and rigidly supported so as to prevent the mixture from squeezing out under the roller. These planks shall remain in place until the final compaction has been obtained. Sections of newly compacted surface course shall be protected from traffic for at least six hours, or until they have become properly hardened by cooling. During the construction of the shoulders, the surface of the pavement shall be kept clean and free from foreign material.

48.23. **Plant and Equipment:** For the determination of the temperatures and quantities of materials used throughout the process of manufacture, the Contractor shall provide and maintain at the plant suitable thermometers, not less than two platform scales, and such other weighing apparatus as is required by the Specifications.

The plant used in preparing all bituminous paving mixtures must be of the batch type capable of mixing in the manner herein specified, and must be provided with separate chambers for heating and mixing the ingredients. No direct heat except steam shall be applied to the exterior surface of the mixing chamber and no flame shall be allowed to pass through the mixing chamber. The heat must be so regulated that the stone and sand can easily be heated to and maintained at the required temperature.

48.24. **Field Laboratory:** The Contractor shall provide a field laboratory in which to house and use the testing equipment, said laboratory to be not less than ten (10) feet wide, twelve (12) feet long and seven (7) feet high, floored; contain not less than two windows and work bench with necessary drawers; this laboratory to be used exclusively for testing purposes by the Enginieer, or Inspector, and shall be so located that the mixing platform shall be in full view of the laboratory.

48.25. **Basis of Payment:** This item will be paid for at the contract unit price per square yard for "Bituminous Concrete Surface Course, (Coarse Aggregate Type,)" which price shall be full compenfor furnishing, handling and placing all materials, and all equipment, tools, labor, and incidentals necessary to complete the item.

Payment will be made under:
Item No. 51, Bituminous Concrete Surface Course (Coarse Aggregate Type) per square yard.

SECTION 49

SAND ROCK ASPHALT SURFACE COURSE

49.01. **Description:** This item shall consist of a wearing course composed of a compacted layer of rock asphalt laid on a "Broken Stone Base Course," "Cement Concrete Base Course," or othert ype of base course specifically approved for this item, and shall be constructed in accordance with these Specifications and in conformity with the lines, grades, compacted thickness, and typical cross-section shown on the plans.

MATERIALS

49.02. **Rock Asphalt:** The rock asphalt shall consist of a natural mixture of mineral aggregate (not less than 90% SiO_2) and bitumen of uniform quality throughout. It shall contain not less than 6.0% of bitumen soluble in cold carbon disulphide when tested in accordance with the Bulletin No. 1216, of the United States Department of Agriculture. The material shall be free from foreign matter and shall be finely pulverized so that not less than ninety-five (95) per cent will pass a one-quarter (¼) inch screen. A uniform percentage of bitumen shall be maintained in the rock asphalt used on each contract. For this reason each shipment must be sampled and tested by the Department's Testing Engineer to determine the percentage of bitumen. No material shall be spread in place upon the road before it has been tested and approved by the Testing Engineer.

CONSTRUCTION METHODS

49.03. **Base Course:** The base course shall be constructed of the cross-section and number of courses shown on the plans and in the manner described for a "Reconstructed Base Course" Section 28 (or) "Broken Stone Base Course," Section 29, Cement Concrete Base Course Section 35.

After the base has been prepared in accordance with these specifications, and prior to the arrival of the surface course mixture on the work, the base course shall have been cleaned of all loose and foreign material for a distance of not less than two hundred (200) feet ahead of the surface course layer. This base shall be maintained at all times clean and free from loose or foreign material, not less than the designated two hundred (200) feet ahead of the point of placing the surface course. The surface of the base course shall be so prepared as to have a rough granular surface which will afford a satisfactory mechanical bond for the rock asphalt surface course. The voids in the surface of the base shall be well defined, exposing the surface of the upper aggregate which shall be thoroughly cleaned and well binded in place.

49.04. **Asphalt Paint Coat.** When the cement concrete foundation is used or rock asphalt surface is used on concrete bridges, the surface of the concrete shall be left rough in order to afford a better anchorage for the surface course. After the concrete has properly cured, the surface shall be thoroughly cleaned and shall be painted with a thin paint coat of approximately sixty-five (65) per cent of Bituminous cement to thirty-five (35) per cent of benzine or gasoline applied at the rate of not more than one-tenth (1/10) of a gallon per square yard. After twenty-four (24) hours the rock asphalt surface shall be laid.

49.05. **Laying Rock Asphalt:** The rock asphalt shall be dumped on dumping boards of approved type and size beside the roadway and spread by hand on the base course to such a depth that after compression it shall have the thickness shown on the plans. The material shall be raked carefully and any lumps broken up until the surface is true to grade and cross-section and free from depressions and irregularities. After raking, the materials shall be left exposed to the sun and air until the surface presents an oily appearance, when it shall be rolled with a well balanced self-propelled roller of the tandem type, weighing between seven (7) and ten (10) tons. The surface shall be thoroughly rolled for at least three (3) consecutive days and until no marks from the roller wheels exist, or longer, if directed. Rock asphalt shall not be laid in wet weather or on days when the temperature is below fifty (50) degrees F. The material shall be thoroughly dry when laid and shall not be laid on a damp base course. Planks of suitable thickness shall be laid along each side of the pavement as directed by Engineer, and rigidly supported so that the rolling operation will not disturb the alignment and grade.

49.06. **Testing Surface:** The surface of the pavement after compression shall be smooth and true to the established crown and grade. Immediately after initial compression the surface shall be tested for conformity with the established crown and grade and by application of a ten (10) foot straight edge parallel to the center line of the roadway, as described elsewhere in this paragraph and any defective places thus disclosed shall be immediately remedied by removing the surface course mixture at such spots, and replacing it with fresh surface course mixture which shall be immediately compacted to conform with the surrounding area.

The finished pavement surface shall show no deviation from the general surface in excess of one-sixteenth (1/16) inch per foot, as measured in the following manner: a ten (10) foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depressions and ordinates measured fom the face of a straight edge to the surface of the pavement shall not exceed one-sixteenth (1/16) inch for each foot in distance from the nearest point of contact.

49.07. Such portions of the completed pavement as are defective in finish, compression, density or composition, or that do not comply in all respects with the requirements of the Specifications, shall be taken up, removed, and replaced with suitable material, properly laid in accordance with these Specifications.

49.08. No rock shall be heated or laid hot until the method and manner of heating shall have been examined by a representative of the company producing the material and it has been found not to be injurious to the material.

49.09. **Basis of Payment:** This item will be paid for at the contract unit price per square yard for "Rock Asphalt Surface Course," complete in place, which price will be full compensation for all materials, equipment, tools, labor and incidentals necessary to complete the item.

Payment will be made Under
Item No. 52, Rock Asphalt Surface Course (square yard).

SECTION 50

BITUMINOUS LIMESTONE SURFACE COURSE (Hot Mix.)

50.01. **Description:** This item shall consist of a one course wearing surface course composed of a compacted layer of Bituminous Limestone laid on a previously prepared base course or subgrade, and shall be constructed in accordance with these specifications and in conformity with the lines, grades, compacted thickness, and typical cross-section shown on the plans.

MATERIALS

Bituminous Cement Flux

(a) Penetration at 77 degrees F., 100 grms., 5 sec., 60 to 100.
(b) Total bitumen soluble in CS^2, at least 99.5%.
(c) Ductility at 73 degrees F., at least 40 c. m.
(d) Loss at 325 degrees F., 5 hrs., Max. 1.0%.

Material for any one contract shall not vary more than two hundredths (0.020) in specific gravity nor more than twenty degrees (20°) F. in melting point, within the test limits above specified. Test of the physical and chemical properties of petroleum asphalt shall be made in accordance with the method prescribed in U. S. Department of Agriculture, Bulletin No. 1216.

CONSTRUCTION METHODS

50.02. **Preparation and Mixing Materials:** The bituminous limestone rock shall be run through a pulverizer, and shall meet the following requirements and be uniformly graded between the limits given:

Passing ¼ inch screen	100%
Passing 10 mesh sieve and retained on 40 mesh sieve	7% to 25%
Passing 40 mesh sieve and retained on 80 mesh sieve	11% to 45%
Passing 80 mesh sieve and retained on 200 mesh sieve	10% to 45%
Passing 200 mesh sieve	50% to 15%

Should the pulverized limestone rock asphalt fail to meet the above requirements, an approved sand or mineral dust, or both shall be added in such quantities, so as to secure an approved grading within the above limits. The aggregates shall be heated in a revolving cylinder to a temperature of not less than three hundred and twenty (320) degrees F., nor more than three hundred and seventy-five (375) degrees F. After heating to a required temperature, and after being weighed into a pug-mill, hot asphalt cement flux shall be added to the batch of bituminous limestone rock asphalt and thoroughly incorporated therein. The total bitumen in the final mix shall be not less than nine (9) per cent nor more than ten and one-half (10½) per cent. The percentage of bitumen in the finished wearing surface shall not show a greater variation than one-half of one per cent, plus or minus, from the amount approved by the Engineer.

The asphaltic cement shall be heated to a temperature not lower than three hundred and twenty (320) nor higher than three hundred and seventy-five (375) degrees F., and shall conform to the following specifications.

50.03. **Placing Rock Asphalt:** After the base has been prepared in accordance with these Specifications and prior to the arrival of the surface course mixture on the work, the base course shall have been cleaned of all loose and foreign material for a distance of not less than two hundred (200) feet ahead of the surface course layer, and this base shall be maintained always clean and free from loose or foreign material not less than the designated two hundred (200) feet ahead of the surface course layer. If at the time of laying surface course permanent side supports such as curbs, edging, or gutter, have not been constructed, planks of suitable thickness shall be laid along each side of the pavement to form an edging and rigidly supported so as to prevent the surface course from being displaced under the roller. These planks shall remain in place until the initial compaction has been obtained. They shall then be removed and the space occupied by them shall be thoroughly tamped full of suitable shoulder material.

The surface course mixture upon being discharged from the pug-mill shall be delivered at the point of spreading at a temperature of not less than two hundred and eighty (280) degrees F., nor more than three hundred and fifty (350) degrees F. It shall be laid on a dry base course and only when the air temperature in the shade and away from artificial heat is fifty (50) degrees Fahrenheit or over, and when the said temperature of the preceding twelve (12) hours has not been lower than forty (40) degrees Fahrenheit.

Upon arrival on the work, the surface course mixture shall be dumped on approved steel dumping boards outside the area on which it is to be spread and shall then be immediately distributed into place by means of shovels and spread with rakes in a uniformly loose layer of such total depth that the weight in pounds of material in each completed square yard of surface course will be one hundred (100), multiplied by the depth in inches required on the plans.

The progress of uniformly distributing the surface course mixture with rakes shall be so conducted that the prongs of the rakes shall thoroughly and completely destroy any compaction which may have occurred in transporting the material from the dumping board and placing the same on the base with shovels. During the initial raking the prongs of the rake shall extend entirely through the surface course mixture to the surface of the base, but care should be exercised not to destroy or loosen the base surface.

The depth of the loose material, unless otherwise permitted or directed shall be gauged by the use of wooden blocks whose minimum dimensions is just equal to the depth of the loose material required. Before rolling, these blocks shall be removed and the space occupied by them filled with surface material of the same quality and consistency as the surrounding material.

The spreading of the material shall be so conducted that it will form a "V" with the vertex at the center line of the road, the sides of the "V" to extend toward the direction of spreading and be at an angle of approximately forty-five (45) degrees with the center of the roadway.

50.04. **Compacting Rock Asphalt:** After the rock asphalt has been spread in a loose layer, as hereinafter provided, true to lines, grades and cross-sections given, it shall be then compacted with a three (3) wheel power roller weighing not less than ten (10) tons or a well balanced self-propelled tandem roller weighing not less than eight (8) tons. Only rollers of the flat wheel type, or the surface of whose wheels, transversely, are in line, will be permitted.

The rolling shall begin at the sides and progress towards the center and parallel to the center line of the roadway, uniformly lapping, by at least twelve (12) inches, each preceding track and shall continue until the entire surface has been covered by the roller and until a monolithic thoroughly compacted surface free from roller marks is produced. If any depressions or irregularities occur during or after the rolling, they shall be corrected by loosening the material with rakes, adding new material when necessary and shall be compacted by re-rolling. Straight edging and back-patching shall be done after initial compression has been secured and while the material is still hot.

50.05. **Testing Surface:** The surface of the pavement after compression shall be smooth and true to the established crown and grade. Immediately after initial compression the surface shall be tested for conformity with the established crown and grade and by application of a ten (10) foot straight edge parallel to the center line of the roadway, as described elsewhere in this paragraph and any defective places thus disclosed shall be immediately remedied by removing the surface course mixture at such spots, and replacing it with fresh surface course mixture which shall be immediately compacted to conform with the surrounding area.

The finished pavement surface shall show no deviation from the general surface in excess of one-sixteenth (1/16) inch per foot, as measured in the following manner: a ten (10) foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depressions and ordinates measured from the face of the straight edge to the surface of the pavement shall not exceed one-sixteenth (1/16) inch for each foot in distance from the nearest point of contact.

50.06. Such portions of the completed pavement as are defective in finish, compression, density or composition, or that do not comply in all respects with the requirements of the specifications, shall be taken up, removed, and replaced with suitable material, properly laid in accordance with these Specifications.

50.07. **Basis of Payment:** This item will be paid for at the contract unit price per square yard for "Bituminous Limerock Surface Course" complete in place, which price shall be full compensation for furnishing all material, for all heating, mixing, hauling, placing, rolling, finishing and for all labor, tools, equipment and incidentals necessary to complete the item.

Payment will be made under
Item No. 53, Bituminous Limerock Surface Course (square yard.)

SECTION 51

SHEET ASPHALT SURFACE COURSE

51.01. **Description:** This item shall consist of an asphaltic binder course one and one-half (1½) inches in thickness, and sheet asphalt wearing surface one and one-half (1½) inches in thickness (unless otherwise specified), and shall be constructed on the prepared base course in accordance with these specifications and in conformity with the lines, grades, and typical cross-section shown on the plans.

MATERIALS

51.02. **Stone:** The broken stone or gravel for asphaltic binder shall consist of clean, tough, durable crushed stone or angular gravel of approved quality. Stone shall have a French coefficient of wear of not less than seven (7). Gravel shall show a loss by abrasion of not more than fifteen (15) per cent when tested as described in U. S. Department of Agriculture Bulletin 1216.

51.03. **Slag:** Broken slag aggregate asphaltic binder shall consist of clean, tough, durable pieces of copper or iron furnace slag, reasonably uniform in density and quality, non-glassy and free from thin or elongated pieces, or any deleterious substance. The dry slag when shaken to refusal shall have a weight per cubic foot of not less than seventy-five (75) pounds and a French coefficient of wear of not less than five and five-tenths (5.5).

51.04. **Grading:** The broken stone, gravel or slag aggregate shall be uniformly graded and when tested by means of laboratory screens, will meet with the following requirements:

Passing 1 inch screen, not less than	95%
Passing 1 inch screen, retained on ½ inch screen	20% to 60%
Passing ½ inch screen, retained on No. 10 sieve	40% to 80%

Particles passing the No. 10 sieve shall be considered as fine aggregate.

51.05. **Fine Aggregate for Binder Course:** The fine aggregate for binder course shall consist of clean, hard, durable particles of sand or mixed stone or slag screenings and sand, free from clay, loam, or other foreign matter. It shall be uniformly graded and when tested shall all pass a No. 10 laboratory sieve and not more than ten (10) per cent shall pass the No. 200 sieve. Screenings of satisfactory quality may be used not to exceed fifty (50) per cent of the fine aggregate by weight.

51.06. **Sand for Surface Course:** The sand shall consist of clean, hard, durable grains and shall be so graded that when tested with standard laboratory sieves it will meet the following requirements by weight:

Passing No. 10 sieve, retained on No. 40	10% to 40%
Passing No. 40 sieve, retained on No. 80	25% to 60%
Passing No. 80 sieve, retained on No. 200	16% to 45%
Passing No. 200 sieve	0% to 6%

These limits shall cover the natural variation in the sources of supply, but the Engineer reserves the right to vary the grading within the limits given as may be rendered necessary by the character of the traffic and other conditions in order to obtain a dense and stable mixture.

51.07. **Mineral Filler:** The filler for sheet asphalt wearing surface shall consist of Portland cement or approved dust prepared from crushed rock, all passing a standard No. 50 laboratory sieve and not less than sixty-seven (67) per cent of which shall pass a No. 200 sieve.

51.08. **Petroleum Asphalt:** All petroleum asphalt shall be homogeneous, free from water and shall not foam when heated to 347 degrees F. It shall meet the following requirements:

(a) Specific gravity at 77 degrees F., at least 1.020.
(b) Flash point, at least 450 degrees F.
(c) Melting point, 113 degrees to 149 degrees F.
(d) Penetration at 77 degrees F., 100 grms., 5 sec., 40 to 50.
(e) Loss at 325 degrees F., 5 hrs., Max. 1.0%.
(f) Penetration residue at 77 degrees F., 100 grms., 5 sec., at least 25.
(g) Total bitumen soluble in CS^2, at least 99.5%.
(h) Organic matter insoluble in CS^2, not over 0.20%.
(i) Ductility at 77 degrees F., at least 30 C. M.

51.09. **Fluxed Bermudez Asphalt:** Fluxed native asphalt shall be homogeneous, free from water and shall not foam when heated to 347 degrees F. It shall meet the following requirements:

(a) Specific gravity at 77 degrees F., 1.055 to 1.075.
(b) Flash point, at least 450 degrees F.
(c) Melting point, 113 degrees to 131 degrees F.
(d) Penetration at 77 degrees F., 100 grms., 5 sec., 40 to 50.
(e) Loss at 325 degrees F., 5 hrs., not over 3.0%.
(f) Penetration of residue 77 degrees F., 100 grms, 5 sec., at least 20.
(g) Total bitumen soluble in CS^2, at least 94.0%.
(h) Inorganic matter insoluble in CS^2, not over 4.0%.

51.10. (e) **Fluxed Trinidad Asphalt:** The fluxed native asphalt shall be homogeneous, free from water and shall not foam when heated to 175 degrees C. (347° F.)

It shall meet the following requirements:

(a) Specific gravity 25 degrees/25 degrees C. (77 degrees/77 degrees F.), 1.210 to 1.270.
(b) Flash point, not less than 175 degrees C. (347 degrees F.)
(c) Melting point 50 degrees C. (122 degrees F.) to 60 degrees C. (140 degrees F.)
(d) Penetration at 25 degrees C. (77 degrees F.) 100 g., 5 sec., 40 to 50.
(e) Loss at 163 degrees C. (325 degrees F.), 5 hrs., not more than 3.0%.
(f) Penetration of residue at 25 degrees C. (77 degrees F.), 100 grms., 5 sec., not less than 20.
(g) Total bitumen (soluble in carbon disulphide), not less than 65.0%.
(h) Inorganic matter insoluble 22.0% to 32.0%.

51.11. **Methods of Testing:** Bituminous materials, except when otherwise noted, shall be sampled and tested in accordance with the Tentative Standard Methods of Sampling and Testing of the American Association of State Highway Officials or U. S. Department of Agriculture Bulletin 1216.

CONSTRUCTION METHODS

51.12. **Plant Inspection:** The refining and preparation of all asphalt and asphaltic mixtures shall be subject to such inspection at the refineries and plants as may be directed by the Engineer.

The Contractor shall furnish and have available at all times at the plant suitable registering thermometric instruments of approved type. Every facility shall be provided for the verification of all scales and measures.

51.13. **Asphaltic Concrete Binder:** Asphalt concrete binder shall consist of asphaltic cement, stone or slag and sand.

51.14. **Composition and Preparation:** The stone and sand as previously specified shall be heated to a temperature of from two hundred and twenty-five (225) degrees F. to three hundred twenty-five (325) degrees F. in approved applicances. The stone and sand shall be measured separately and then mixed with sufficient asphaltic cement prepared as herein specified, in such proportions that the resulting mixture will contain the several materials within the following limits:

Stone passing one inch circular opening	95%
Stone passing one-half inch circular opening	35% to 75%
Stone passing one-half inch circular opening and retained on a No. 10 sieve	20% to 45%
Passing No. 10 sieve	15% to 35%
Bitumen as directed	4% to 6%

51.15. **Heating of Bituminous Material:** The Bituminous material shall be heated in tanks or kettles so designed as to admit of even heating of the entire mass, with an efficient and positive control of the heat at all times. It shall be heated as directed to a temperature of between two hundred and seventy-five (275) degrees F. and three hundred and fifty (350) degrees F.

51.16. **Asphaltic Surface Mixtures:** The asphaltic surfaces mixture shall consist of asphaltic cement, sand and Portland cement or stone dust. The mixture shall be proportioned to contain the several materials in average proportions, by weight, of the whole mixture as follows:

Sand passing No. 10 sieve, retained on No. 40	8% to 33%
Sand passing No. 40 sieve, retained on No. 80	20% to 48%
Sand passing No. 80 sieve, retained on No. 200	12% to 36%
Filler passing No. 200 sieve	10% to 15%
Bitumen soluble in cold carbon disulphide	9% to 12%

The bitumen and filler will be varied within the limits designated, at the direction of the Engineer.

The item designated as "Filler" within the limits named herein includes, in addition to the Portland cement or stone dust, fine sand passing No. 200 sieve not exceeding four and one-half (4½) per cent of the entire mixture, and mineral dust naturally contained in the refined asphalt.

When indicated on the plans the addition of materials required by patented processes will be permitted, in which case the price per square yard will cover all materials, labor, equipment, tools, royalties and other work incidental thereto.

51.17. **Preparation of Asphaltic Surface Mixture:** The sand and asphaltic cement shall be heated separately to a temperature of approximately three hundred (300) degrees F. The maximum temperature of the sand at the mixer in no case shall be over four hundred (400) degrees F., and the maximum temperature of the asphaltic cement shall not exceed three hundred and fifty (350) degrees F. at the discharge pipe. The filler shall be added to and mixed thoroughly with the hot sand, after which the asphaltic cement, in the required proportion, shall be added and the mixing continued for at least one (1) minute in a suitable apparatus until a homogeneous mixture is produced, in which all the particles are coated uniformly.

The required quantity of asphaltic cement shall be measured at all times by actual weighing with scales attached to the asphaltic cement bucket. The Portland cement or stone dust and sand also must be weighed unless approved method of guaging is used.

51.18 **Delivery of Binder:** The asphaltic concrete binder shall be hauled to the work in tight, clean vehicles provided with canvas covers large enough to protect the entire load. When delivered at the work it shall have a temperature of between two hundred and fifty (250) and three hundred fifty (350) degrees F., regulated according to the air temperature and working of the binder.

51.19. **Placing Binder:** The binder shall be laid only on a base course which is dry and free from all loose and foreign material, and only when the rising air temperature is above thirty-nine (39) degrees F. in the shade, or when the falling air temperature is above forty-four (44) degrees F. in the shade.

It shall be dumped upon a suitable dumping board and shovelled into place or spread by an approved spreader. If shovelled, the mixture shall be handled with hot shovels and so placed as to prevent segregation and non-uniform compaction. In depositing the binder, each shovel will be turned over and the end of the shovel brought to rest on the base as the mixture is placed. As the mixture is placed with shovels it shall be combed from top to bottom with a rake having tines at least five inches (5") long and at least two inches (2") apart. It shall then be spread to a uniform surface and to such depth that after being thoroughly compacted it shall have a depth as shown on the plans, and parallel to finished surface of the pavement.

51.20. **Forms:** Planks of suitable thickness shall be laid along each side of the pavement as directed by Engineer, and rigidly supported so that the rolling operation will not disturb the alignment and grade.

51.21. **Compacting Binder:** While still hot, the binder course shall be thoroughly and uniformly compressed. The initial rolling of the binder course shall always be secured with a ten (10) ton three (3) wheel power roller, with a rear wheel compression of not less than three hundred and fifty (350) pounds per lineal inch of width of tires, but final compression shall always be secured with a power driven tandem roller weighing not less than seven (7) tons.

All rollers used shall be kept in good condition. Each roller shall be in charge of and operated by a competent, experienced rollerman, and must be kept in continuous operation as nearly as is practicable.

The ashes from any roller must not be dumped upon the binder course. Rolling shall start longitudinally at the sides, and proceed towards the center of the pavement, lapping on successive trips by at least one-half (½) the width of the roller wheel. The binder course shall then be subjected to diagonal rolling in two directions, the second diagonal rolling crossing the lines of the first diagonal rolling at as near right angles as is practicable, and at about forty-five (45) degrees angle with the center line. Rolling shall be continued until all roller marks are eliminated and the binder has been compressed to maximum density. The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture and any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall at once be corrected by the use of rakes and of fresh mixture where required. Rolling shall proceed at an average rate of not to exceed two hundred (200) square yards per hour per roller continuous rolling for each roller, weighing not less than ten (10) tons, and shall continue until no further compression is possible. To prevent adhesion of the binder mixture to the roller, the wheels shall be kept properly moistened but an excess of either oil or water will not be permitted. Any binder broken up during the process of laying or rolling, or remaining unbonded after rolling shall be removed and replaced with new material.

When deemed necessary the binder course shall be covered with the surface course the same day as laid, and at no time shall there be laid more binder than can be covered by the following day's run of the plant.

Along curbs, headers, and similar structures and all places not accessible to the roller, the binder course shall be thoroughly compacted with hot iron tampers weighing not less than twenty-five (25) pounds, and having a bearing area not exceeding forty-eight (48) square inches.

The surface of the binder after compression shall be smooth, even and true to the established lines, grades, and cross-section. Any depressions or high spots shall be immediately remedied by removing the binder course mixture at such spots, and replacing it with fresh binder course mixture which shall be immediately compacted to conform with the surrounding area.

The finished binder course shall show no deviation from the general surface in excess of one-sixteenth (1/16) inch per foot, as measured in the following manner: a ten (10) foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depressions, and ordinances measured from the face of the straight edge to the surface of the binder course shall not exceed one-sixteenth (1/16) inch for each foot in distance from the nearest point of contact.

51.22. **Delivery and Placing Surface Mixture:** The surface mixture shall be delivered in the same manner as specified for the binder. A turn table will be used for turning trucks in order to avoid disturbance of the binder course. It shall be laid only on binder which is dry and free from loose or foreign materials, and only when the rising air temperature is above thirty-nine (39) degrees F. in the shade or when the falling air temperature is above forty-four (44) degrees F. in the shade. Contact surfaces of curbs, manholes, and other structures shall be uniformly painted with hot asphaltic cement before surface course is spread. The mixture shall be delivered at a temperature of between two hundred and seventy-five (275) to three hundred and seventy-five (375) degrees F., and a fire box shall be kept near the work so that tools for handling the mixture may be kept hot. The mixture shall be dumped upon a suitable dumping board, and then shoveled into place with hot shovels, each shovel being turned over and the end brought to rest on the binder as the surface mixture is deposited. It shall then be thoroughly combed from top to bottom with a rake having tines at least five (5) inches long and at least two (2) inches apart, then raked with fine rakes by competent and experienced rakers to grade in a uniformly loose layer of such depth that after rolling it shall have the depth shown on the plans. The surface of the pavement shall be left slightly higher than manholes, curbs, headers, etc. The surface course shall generally be placed the same day as the binder course.

51.23. **Compacting Surface Course:**

(a) While still hot the surface course shall first be thoroughly and uniformly compressed by a power driven three-wheeled roller weighing not less than ten (10) tons and having a rear wheel compression of not less than three hundred and fifty (350) pounds per lineal inch or width of tire. Subsequent compression may be obtained by a power driven tandem roller weighing not less than seven (7) tons. Rolling shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least one-half (½) the width of the rear wheel of the roller. The pavement shall then be subjected to diagonal rolling in two directions with a tandem roller, the second diagonal rolling across in the lines of the first. If the width of the pavement permits, it shall in addition be rolled at right angles to the center line. Rolling shall be continued until all roller marks are eliminated. The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture and any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall at once be corrected by the use of rakes and of fresh mixture where required. Rolling shall proceed at an average rate of not to exceed two hundred (200) square yards per hour per roller, continuous rolling for each roller weighing not less than ten (10) tons, and shall continue until no further compression is possible, and the surface mixture has a density of not less than ninety-four (94) per cent of the theoretical density. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept properly moistened, but excess of either water or oil will not be permitted. After final compression a light uniform coating of limestone dust or Portland cement shall be swept over the surface of the pavement and the rolling then continued.

(b) Along curbs, headers and similar structures and at all places not accessible to the roller the surface mixture shall be thoroughly compacted with hot tampers to produce sealed joints.

51.24. **Testing Surface:** The surface of the pavement after compression shall be smooth and true to the established crown and grade. Immediately after initial compression the surface shall be tested by the Contractor for conformity with the established crown and grade and by application of a ten (10) foot straight edge parallel to the center line of the roadway, as described elsewhere in this paragraph and any defective places thus disclosed shall be immediately remedied by removing the surface course mixture at such spots, and replacing it with hot, fresh surface course mixture which shall be immediately compacted to conform with the surrounding area.

The finished pavement surface shall show no deviation from the general surface in excess of one-sixteenth (1/16) inch per foot, as measured in the following manner: a ten (10) foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depressions, and ordinates measured from the face of the straight edge to the surface of the pavement shall not exceed one-sixteenth (1/16) inch for each foot in distance from nearest point of contact.

51.25. **Joints:** Placing of the surface course shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is discontinued for such length of time as to permit the mixture to become chilled. In all such cases when the work is resumed, the material laid shall be cut back so as to produce a slightly beveled edge for the full thickness of the course. The old material which has been cut away shall be removed from the work and new mix laid against the fresh cut. If desired a stout rope may be stretched across the pavement where the joint is to be made. When the work is resumed, the material laid shall be cut back to the rope which will be removed together with the surplus material and the fresh mix laid against the joint thus formed. Hot smoothing irons may be used for sealing joints, but in such case, extreme care shall be exercised to avoid burning the surface.

51.26. Such portions of the completed pavement as are defective in finish, compression, density, or composition, or that do not comply in all respects with the requirements of the Specifications, shall be taken up, removed, and replaced with suitable material, properly laid in accordance with these Specifications at the expense of the Contractor.

51.27. **Finishing:** All projections, joints, and honey-combed surface shall be ironed smooth to grade and Portland cement or limestone dust shall be swept evenly over the entire surface.

51.28. **Protection from Traffic:** After the surface mixture has received its final rolling, no traffic shall be permitted on the pavement until it shall have hardened sufficiently and in no case less than six (6) hours after being placed.

51.29. **Basis of Payment:** This item will be paid for at the contract unit price per square yard for "Sheet Asphalt Surface Course," complete in place, which price will be full compensation for furnishing, hauling, and placing all materials, for all equipment, tools, labor and incidentals necessary to complete the item.

Payment will be made under
Item No. 54, Sheet Asphalt Suface Course (square yard).

SECTION 52

BITUMINOUS FILLED BRICK PAVEMENT

52.01. **Description:** This item shall consist of a vitrified brick pavement with a bituminous filler and sand bed, laid on a cement concrete base course or other base course specifically approved for this pavement, and shall be constructed in accordance with these specifications and in conformity with the lines, grades, and typical cross-section shown on the plans.

MATERIALS

52.02. (b) **Paving Brick:** Brick to be used in the wearing surfaces shall conform to the requirements of the Standard Specifications for Paving Brick, Serial Designation C7-15, of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the Society, except that sampling shall conform to the requirements for "Sampling of Paving Brick" as provided in the Tentative Standard Methods of Sampling and Testing of the American Association of State Highway Officials.

The brick used shall be one of the varieties recommended by the Standing Committee on Simplification of Varieties of Vitrified Paving Brick of the Department of Commerce of the United States. The following varieties were adopted on March 28, 1924, and are subject to annual revision.

VARIETIES

(Sizes in Inches)

Plain wire-cut brick (vertical fiber lugless) as usually laid:

Width	Depth	Length
4	2½	8½
4	3	8½
4	3½	8½

Wire-cut lug brick (Dunn):

Width	Depth	Length
3½	4	8½

Repressed lug brick:

Width	Depth	Length
3½	4	8½

Variations from the specified dimensions shall not exceed 1/8 inch in width and depth and ½ inch in length.

All bricks shall be thoroughly annealed, tough, durable, regular in size and shape, and evenly burned. When broken they shall show a dense, stone-like body, free from lime, air pockets, cracks or marked laminations. Kiln marks or surface cracks shall not exceed 3/16 of an inch in depth, and the wearing surface shall show no cracks and only slight kiln marks. The bricks shall be straight, with at least one suitable wearing surface, and no brick so distorted as to lie unevenly in the pavement shall be used.

When subjected to the rattler test, in accordance with Specifications of American Society of Testing Materials Serial C-7-15, the average loss by abrasion shall not exceed the following:

Size of Brick	Repressed	Wire-Cut
4 x 3½ x 8½		23%
4 x 3 x 8½		25%
2½ x 4 x 8½		27%
3½ x 4 x 8½	22%	

The maximum loss on any one sample shall be not more than 2% higher than the above average losses.

The ends of the brick may be double-beveled not more than 1/8 of an inch. If the edges are rounded, the radius shall not exceed 3/16 of an inch. Lugs, if any, shall be not less than two nor more than four in number, extending from the body of the brick not more than ¼ of an inch. If lettering appears on the brick, the letters shall be recessed.

The bricks shall be subject to visual inspection, subsequent to delivery at the place of use, prior to and during laying. The Inspector shall cull out and reject all bricks not meeting requirements upon the following grounds:

All bricks not meeting general and dimension clauses herein given.

All bricks which are broken through, or chipped in such a manner that neither wearing surface remains substantially intact, or in such manner that the lower or bearing surface is reduced in area by more than one-eighth (1/8).

All bricks which are cracked to a depth greater than three-eighths (3/8) inch on any surface.

All bricks which are off-size or so mis-shapen, bent, twisted or kiln-marked that they will not form a proper surface or align properly with other bricks.

All bricks which are obviously too soft and too poorly vitrified to endure road wear.

52.03. **Sand:** Sand for sand bed shall consist of hard, durable grains, free from vegetable and other deleterious substances. When dry it shall pass a one-quarter (¼) inch laboratory sieve and shall be well graded from coarse to fine. The material removed by the elutriation test shall not exceed five (5) per cent by weight. Granulated slag, slag screenings or limestone screenings meeting the above specifications may be used in place of sand.

52.04. **Petroleum Asphalt:** All petroleum asphalt shall be homogeneous, free from water and shall not foam when heated to three hundred and forty-seven (347) degrees F. It shall meet the following requirements for filling vitrified brick:

(a) Flash point, at least 392 degrees F.
(b) Melting point, 149 degrees F. to 230 degrees F.
(c) Penetration at 77 degrees F., 100 grms., 5 secs., 30 to 50.
(d) Loss at 325 degrees F., 5 hrs., Max. 1.0%.
(e) Penetration residue at 77 degrees F., 100 grms., 5 secs., at least 20.
(f) Total bitumen soluable in CS_2, at least 99.5%.
(g) Ductility at 77 degrees F., at least 30 C. M.

CONSTRUCTION METHODS

52.05. The prescribed curbing or edging will be constructed integrally with the base course.

52.06. **Placing Sand Bed:** Upon the prepared base course which shall be cleaned of all loose and foreign materials shall be spread a sand bed of the thickness shown on the plans.

52.07. Bedding shall be shaped to a true surface parallel with the proposed surface of the finished roadway by means of a template extending the entire width of the roadway, drawn forward upon the curbs or other guide rails as provided. When the width of the roadway precludes the use of a template spanning the entire distance, the bedding shall be shaped in sections, using scantlings laid upon the base as guide-rails. The bedding course shall be struck off at least twice with the template. Any depressions which develop shall be filled in and the bed again struck off with the template. This operation shall be continued until perfect alignment is presented.

52.08. In addition to shaping with a template, the bedding course shall also be compacted with a hand roller. The roller shall be not less than thirty-six (36) inches in diameter, twenty-four (24) inches in width and weight not less than ten (10) pounds per inch of width. In such case the bedding course shall be rolled after striking off. All depressions which develop shall be filled in, struck off with the template and again rolled. This operation shall be repeated until perfect alignment is presented.

52.09. When the use of the template and guide rails is impracticable in finishing the bedding surface, it shall be shaped to the surface required by hand lutes.

52.10. The bedding shall not be disturbed after final shaping prior to laying the brick. Sand bed which is injured or displaced by the flow of water, rain, or by any other cause shall be satisfactorily replaced.

52.11. **Laying Brick:** Brick shall be handled carefully. When piled by the roadside, they shall be so protected that they will not become spattered with earth or mud. All brick shall be kept scrupulously clean until the pavement is finished. No wheeling in barrows will be allowed on the brick surface. Brick shall be carried on pallets, in brick clamps, or on mechanical conveyors in such order that when delivered to the dropper they will lie so that in the regular operation of placing them on the sand bed the better face or side will be upward.

52.12. Upon the sand bed as approved the bricks shall be laid immediately with the best face up, lugs, if any, in the same direction, from one side of the pavement to the other side, in parallel straight courses at right angles to the center line, except at intersections and on curves, where they shall be laid as directed by the Engineer. The bricks shall be laid with both ends and sides in contact, breaking joints not less than three (3) inches. The courses shall be straightened by striking lightly with a sledge on a four (4) by four (4) inch timber three (3) feet long, placed against every fourth course, all thick bricks being removed. At the end of courses, and where necessary between courses, closures shall be made by carefully placing brick cut accurately to give close joints. Cut or broken bricks shall be used only at the end of courses, placed with the cut end turned toward the adjacent whole brick and shall be not less than three (3) inches in length. While laying bricks the pavers shall not walk or stand on the bed. The spaces between the bricks shall be kept clean and open to the bottom until the filler is applied. After laying, the brick shall be inspected, culled and approved before rolling, and if any section contains more than ten (10) per cent of culls, the bricks shall be removed and the bed replaced.

52.13. Hillside bricks shall be laid as above specified with the grooves across the line of traffic and the square edge upgrade.

52.14. **Rolling Bricks:** Before rolling, the surface of the bricks shall be swept free of spalls. The pavement shall then be rolled with a tamden roller weighing not less than three (3) nor more than five (5) tons, commencing at the sides and proceeding slowly back and forth, parallel to the sides, until the center of the pavement is reached; then passing to the opposite side the rolling shall be repeated in the same manner until the center is again reached, after which the speed may be increased, the rolling continued until the bricks are bedded firmly. The rolling shall then be done obliquely from one side of the pavement to the other side, repeating this operation in the opposite direction. All bricks which are broken or injured during rolling shall be removed and replaced with perfect ones, which likewise shall be brought to the true surface. The bricks adjacent to curbing and other areas inaccessible to the roller shall be tamped to grade by the use of a hand tamper, applied upon a two (2) inch board. If the bed is forced up between the bricks more than one-half (½) inch, the bricks shall be removed and the bed reshaped.

52.15. After final rolling the pavement shall be tested with a template laid transversely and a ten (10) foot straight edge, laid parallel with the center line of the pavement, and any depressions exceeding the allowance of the surface test hereinafter prescribed shall be corrected and, if necessary, the entire surrounding surface again rolled.

52.16. **Applying Bituminous Filler:** After the brick have been rolled thoroughly, inspected and approved, the spaces between them shall be filled with the hot asphalt filler.

52.17. The filler shall be heated in kettles so designed as to admit of an even heating of the entire mass, with an efficient and positive control of the heat at all times. It shall be heated as directed to a temperature between three hundred (300) degrees F. and three hundred and seventy-five (375) degrees F. The Contractor shall provide a sufficient number of accurate, efficient thermometers for determining the temperature of the filler in kettles.

52.18. Brick shall be clean and dry when the filler is applied. Immediately before filling the joints, the surface of the brick shall be swept clean. All brick shall be filled and a surface dressing applied on the day of laying. Filler shall not be applied if the brick are wet nor if the air temperatures are such that the filler will not flow freely into the joints.

52.19. Filler shallbe removed from the heater and applied promptly to the pavement before cooling. Filler shall be worked into the joints by means of squeegees operated slowly backward and forward at an angle with the joints. Squeegeeing shall continue until the joints appear full and a thin coating of asphalt remains upon the surface of the brick.

52.20. While the filler is still soft and pliable, the pavement shall be covered with a thin layer of dry stone screenings, slag screenings, sand or granulated slag. Top dressing shall be of such sizes that all will pass a one-quarter (¼) inch sieve. As soon as the dressing is spread, the surface of the pavement shall be rolled thoroughly to bed the dressing into the asphalt coating.

52.21. The finished pavement surface shall show no deviation from the general surface in excess of one-sixteenth (1/16) inch per foot, as measured in the following manner: A ten (10) foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depressions, and ordinates measured from the face of the straight edge to the surface of the pavement shall not exceed one-sixteenth (1/16) inch for each foot in distance from the nearest point of contact.

Traffic shall not be permitted on the pavement until the filler has cooled to the air temperature.

52.22. **Nose Brick:** Suitable nose brick of quality approved by the Engineer shall be used on the guage side of trolley rails, as shown on Plans.

52.23. **Method of Measurement:** In the measurement of Brick Pavement no deductions shall be made for areas occupied by rails, manhole covers, or other similar surface structures. All linear measurements for computing pay yardage will be made directly on the finished surface of the pavement. The pay yardage shall be the square yardage of pavement laid which has been accepted by the Engineer.

52.24. **Basis of Payment:** This item will be paid for at the contract unit price per square yard for "Bituminous Filled Brick Pavement," which price shall be full compensation for furnishing, delivering, and placing all material, for all labor, equipment, tools and incidentals necessary to complete the item.

Payment will be made under
Item No. 55, Bituminous Filled Brick Pavement (square yard).

SECTION 53

PLAIN CEMENT CONCRETE PAVEMENT

53.01. **Description:** This item shall consist of Portland cement concrete and shall be constructed on the prepared subgrade or completed base course in accordance with these Specifications and in conformity with the lines, grade, thickness, and typical cross-section shown on the plans. The concrete shall be composed of one part Portland cement and five and one-half (5½) parts of fine and coarse aggregates, each measured separately by volume or by weight.

MATERIALS

CEMENT

53.02. **Portland Cement:** All cement used in the work shall conform to the requirements of the "Standard Specifications and Tests for Portland Cement" adopted by the American Society for Testing Materials—serial designation C-9-26, as modified and amended from time to time by the American Association of State Highway Officials.

Each shipment or lot of cement used on the work shall be sampled and tested in accordance with the amended "Standard Specifications and Tests" above designated. All cement used shall be shipped in cotton cloth bags.

53.03. **Storage of Cement:** The Contractor shall provide suitable means for storing and protecting the cement against dampness. When cement is furnished by the State, any that has been damaged because of the failure of the Contractor to provide suitable storage shall be paid for by the Contractor. Different brands or grades of cement must be stored separately.

53.04. **Damaged Cement:** Bags of cement, which for any reason have become partially set, or which contain lumps or caked cement,shall be rejected. In no instance will any portion of a bag of damaged cement, or a bag containing lumps of caked cement, be used.

Cement salvaged from discarded or used sacks will not be permitted to be used.

53.05. **Ordering Excess Cement:** The Contractor shall be held responsible for ordering the correct amount of cement, and if the cement is being furnished by the State, the Contractor shall be charged the net price paid by the State for the Excess cement after the completion of any contract, which excess shall become the property of the Contractor.

53.06. **Mixing Different Cements:** Different brands of cements, even if tested and approved, shall not be mixed during use, or used alternately, in any one class of construction.

53.08. **Water:** The water used in mortar or concrete shall be subjected to the approval of the Engineer, and shall be fresh, reasonably clear, free from oil, acid, salt, strong alkali or vegetable matter. Tests of water shall be made in accordance with the requirements of United States Department of Agriculture, Bulletin 1216 of May 1924 with subsequent revisions.

53.09. **Fine Aggregates:** Fine aggregates shall consist of sand, having clean, hard, strong, durable uncoated grains, free from injurious amounts of clay lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances.

Fine aggregate shall preferably be graded from fine to coarse with the coarser particles predominating, within the following limits:

Passing No. 4 sieve	100%
Passing No. 20 sieve	50 to 75%
Passing No. 50 sieve, not more than	30%
Passing No. 50 sieve, not less than	5%
Passing No. 100 sieve, not more than	5%
Weight removed by elutriation test, not more than	3%

Sieves shall conform to the requirements specified in the "Standard Method of Test for Sieve Analysis of Aggregates for Concrete," serial designation C-41-24 of the American Society for Testing Materials.

53.10. **Strength Test of Fine Aggregate:** Mortar composed of one (1) part, by weight, of cement and three (3) parts, by weight, of sand, mixed and tested in accordance with the methods referred to in the U. S. Department of Agriculture Bulletin No. 1216, page 14, etc., shall have tensile strength at the age of seven (7) and twenty-eight (28) days of one hundred (100) per cent of the tensile strength developed in the same time by mortar of the same proportions and consistency, made with the same cement and "Standard" Ottowa sand.

Sands failing to meet the mortar strength tests, but otherwise conforming to specifications, may be used provided the strength requirements set forth in Paragraph 53.28 are fulfilled.

Preliminary acceptance samples shall be subjected to both seven (7) and twenty-eight (28) day tests and acceptance based thereon. Samples tested during the progress of the work will be accepted on the basis of the seven (7) day test.

53.11. **Organic Matter:** No fine aggregate showing a color darker than the standard color when tested in accordance with the Standard Method of Test for Organic Impurities in Sands for Concrete, serial designation C-40-22 of the American Society for Testing Materials or U. S. Department of Agriculture Bulletin No. 1216 shall be used unless the strength requirements of Paragraph 53.28 is fulfilled.

53.12. **Coarse Aggregate.** The coarse aggregates shall consist of clean, hard, durable crushed stone, gravel or slag free from any coating of clay or slime. Material containing organic matter, thin elongated particles, clay or other deleterious substance, may be rejected by the Engineer without testing.

53.13. **Crushed Stone:** Crushed stone shall be obtained from clean tough, sound durable rock having a French Coefficient of wear of not less than six (6). The material shall be free from dust and an excess of flat and elongated pieces. Stone shall meet the accelerated soundness test described in U. S. Department of Agriculture, Bulletin No. 1216, of May 1924 with subsequent additions.

53.14. **Gravel:** Shall consist of clean, tough, durable stone of high resistance to abrasion, free of clay or coatings of any character. "Run of Bank" gravel or gravel which contains disintegrated or soft stone or shale, or excess of flat pieces shall not be used. The loss by abrasion shall not be more than twenty (20) per cent, when tested as described in U. S. Department of Agriculture Bulletin No. 1216.

53.15. **Slag:** Broken slag aggregate shall consist of clean, tough, durable pieces of copper or iron furnace slag, reasonably uniform in density and quality, non-glassy and free from thin elongated pieces or any deleterious substance. The dry slag when shaken to refusal shall have a weight per cubic foot of not less than seventy-five (75) pounds, and a French coefficient of wear of not less than five and five-tenths (5.5).

53.16. **Method of Tests:** Method of sampling and testing shall be in conformance with the practice recommended by the "Committee on Test and Investigations" of the American Association of State Highway officials or U. S. Department of Agriculture, Bulletin 1216.

53.17. **Grading:** Coarse aggregate shall be uniformly graded between the limits specified and shall meet the following requirements:

Passing a 2½-inch screen	100%
Passing a 2 -inch screen	80-100%
Passing a 1 -inch screen	40- 75%
Passing a ¼-inch screen	0- 5%

53.18. **Petroleum Asphalt Joint Filler:** Shall be homogeneous, free from water and shall not foam when heated to three hundred and forty-seven (347) degrees F. and shall meet the following requirements:

(a) Flash point, at least 392 degrees F.
(b) Melting point, 149 degrees to 230 degrees F.
(c) Penetration at 77 degrees F., 100 grms., 5 secs., 30 to 50.
(d) Loss at 325 degrees F., 5 hrs., Max. 1.0%.
(e) Penetration residue at 77 degrees F., 100 grms., 5 secs., at least 20.
(f) Total bitumen soluble in CS_2, at least 99.5%.
(g) Ductility at 77 degrees F., at least 30 C. M.

53.19. **Premolded Expansion Joint: General:** The bituminous premolded joint shall be of the dimensions shown on the plans or in the estimate and shall be of asphalt or tar composition of approved quality. The joint shall be of such character that it will not be deformed by ordinary handling during the hot summer months or become hard and brittle in cold weather. Thin strips of stiffener will be allowed.

The bitumen shall be uniformly impregnated with suitable filler to reduce its brittleness at low temperature to a minimum

(a) **Absorption:** When a specimen two (2) by six (6) inches cut from the joint material is immersed in water for twenty-four (24) hours it shall absorb not more than five (5) per cent by weight.

(b) **Brittleness:** The bituminous premolded joint shall not crack or shatter when subjected to the following tests.

The sample to be tested, two (2) inches by six (6) inches, is clamped between two (2) boards so that the expansion joint cantilevers three and one-half (3½) inches, same being held in any suitable support. A cast iron ball weighing ninety-five one hundredths (0.95) pound and having a diameter of one and eight hundred and seventy-five thousandths (1.875) inches is suspended by a cord which is tied to an eyelet soldered to the ball. For samples having a thickness of one-half (½) inch and less, the ball is suspended one foot above the center of the projected portion of the specimen. For samples over one-half (½) inch in thickness the ball is suspended two (2) feet above the specimen. The ball is released by burning the string above the eyelet. The test is made on the sample after it has been maintained at a temperature of from four (4) degrees to six (6) degrees C, for at least two (2) hours prior to testing.

(c) **Distortions:** The samples shall not show a deflection from horizontal of more than one (1) inch when subjected to the following test. The sample two (2) inches by six (6) inches absolutely flat and straight is clamped between two blocks so that the expansion joint cantilevers three and five tenths (3.5) inches. The clamp, with the expansion joint is then placed in an oven at 125 degrees F. and left therein for two (2) hours.

53.20. **Curing Agents:**

(a) **Calcium Chloride:** The calcium chloride shall contain from seventy-three (73) per cent to seventy-five (75) per cent of pure anhydrous calcium chloride and shall not contain more than five-tenths (0.5) per cent magnesium chloride, two (2.0) per cent sodium chloride, and not more than one (1.0) per cent of other impurities. It shall be packed in moisture-proof bags or in air-tight drums. The calcium chloride shall be in the flake or granulated form and fine enough to feed readily through the approved spreading machine used for this work. When tested by means of laboratory screens, it shall meet the following requirements:

Passing 3/8 inch mesh screen	100%
Passing a ¼ inch seive not less than	80%
Passing 20 mesh sieve, not more than	10%

(b) **Silicate of Soda:** Sodium silicate having a ratio of one (1) Na_2O (Sodium Oxide) to three and two-tenths (3.2) SiO_2 (Silica) shall be shipped in sealed drums or tank cars and shall have a density of between 42.25 degrees and 42.75 degrees Be at 60 degrees F. Three (3) parts of the silicate of soda shall be diluted with one (1) part of water so as to give a density of between 36 degrees and 37 degrees Be, at 60° F. and the mixture thoroughly agitated. Suitable volume measures will be used for the accurate proportioning of water and silicate of soda.

CONSTRUCTION METHODS

53.21. **Storage of Aggregates:** If materials are stock piled, such piles shall be built up in layers not to exceed three (3) feet in height and each layer shall be completely in place before beginning on the next. Coning or building up of stock piles by depositing material in one place will not be permitted.

Different types of aggregates must be stored separately. Stone and gravel must be kept separate, and shall be stored in separate stock piles.

The storing of loads or piles of either fine or coarse aggregates upon the subgrade or upon the shoulders immediately adjacent thereto to be wheeled, shoveled, or conveyed directly to the mixer will not be permitted.

53.22. **Devices for Measuring Materials:** The accurate measurement of each of the materials composing, and the production of a uniform mixture of the concrete are essential. The Contractor shall furnish and use approved timing devices, a water measuring and discharging device, also batch measuring equipment which will give the exact amount of aggregate required by the Engineer. The cement shall be measured as packed by the manufacturer, a sack containing not less than ninety-four (94) pounds being considered one (1) cubic foot.

53.23. **Forms:** Outside forms for this work shall be of metal, of the depth of the concrete, straight, free from warp, and of sufficient strength when staked to carry the mechanical tamping and finishing device and to resist the pressure of the concrete without springing. They shall be of approved section and have a flat surface on top of not less than one and three-fourth (1¾) inches. The forms shall be joined neatly and tightly and staked to line and grade at least two hundred (200) feet in advance of the points of placing concrete, and shall be cleaned thoroughly and lubricated before any concrete is deposited against them. They shall be so secured that the mechanical tamping device used will not cause them to settle or get out of alignment. Forms, the top surface of which show a variation in excess of one-fourth (¼) inch when tested with a ten (10) foot straight edge, shall be rejected.

53.24. **Wooden Forms:** Wooden forms may be used for curves having a radius of one hundred and fifty (150) feet, or less. Wooden forms shall be made of two (2) inch, well-seasoned, surfaced plank.

53.25. **Composition of Concrete:** Fine and coarse aggregate shall be measured separately by volume or by weight with approved measuring devices. The amount of aggregate used shall be the equivalent of loose volume measurement, correction being made for bulking of damp sand and for the water in the aggregates in case the measurement is made by weight. The cement shall be measured as packed by the manufacturer, a sack containing not less than ninety-four (94) pounds being considered one (1) cubic foot.

Concrete shall be composed of one (1) part of cement and five and one-half (5½) parts of fine and coarse aggregates measured separately. The ratio of fine and coarse aggregate shall be determined by the Engineer for the particular aggregates to be used but the ratio of fine aggregate to cement shall not be more than one (1) part cement to two and one-fourth (2¼) parts of fine aggregate.

53.26. **Consistency of Concrete:** The consistency of the mixed concrete shall be uniform and such that the mortar shall cling to the coarse aggregate. It shall not be sufficiently wet to flow readily and segregate, nor of a mealy, dry consistency. When the mixed concrete is allowed to drop directly from the discharge chute to the ground, the concrete shall sink into the center of the pile, the top of the pile flatten and the edges stand up. The water in all cases shall be measured and gauged accurately and shall be discharged automatically into the drum with the aggregate. The quantity of water shall be determined by the Engineer and shall not be varied without his consent.

Consistency of the concrete shall be determined by the slump test made in the following manner: The mould, which consists of a cone of metal twelve (12) inches high, eight (8) inches in diameter at the bottom and four (4) inches in diameter at the top, with both ends open and having a handle or bail by which it may be lifted vertically, is placed on a smooth non absorbent surface and firmly held in place during filling. A sample mixture of the mix is deposited in three layers, each layer being carefully tamped by twenty-five strokes of a pointed five-eighths (5/8) inch rod. The top of the mould should be struck off evenly and the mould lifted with a steady, vertical pull immediate after striking. The mould should then be set beside the cone of concrete and a straight–edge placed across the top and extending over the cone of concrete. The distance from the lower side of the straight–edge to the top of the cone of concrete gives the difference in height and is the amount of slump. This should not be less than three-quarters (¾) of an inch nor more than one and one-half (1½) inches. The amount of water shall be determined by the foregoing test by the Engineer and shall not be varied without his consent. It shall be accurately measured and gauged and shall be automatically discharged into the drum with the aggregates.

53.27. **Mixing Conditions of Concrete:** No concrete shall be mixed while the air temperature in the shade and away from artificial heat is as low as forty (40) degrees Fahrenheit and falling. Concrete may be mixed and placed when the air temperature in the shade and away from artificial heat is thirty-five (35) degrees Fahrenheit, and rising. No materials containing frost shall be used. Bags of cement, or fine aggregate, containing lumps or crust of hard material shall not be used. The concrete shall be mixed only in such quantity as is required for immediate use and any which has developed initial set, or has been mixed longer than thirty (30) minutes, before being deposited in place, shall not be used. No concrete shall be placed on a frozen subgrade.

53.28. **Quality of Concrete:** In case the desired density or strength cannot be obtained from the concrete mixed as heretofore described the Engineer may vary the relative proportions of fine and coarse aggregate or increase the amount of cement to secure the desired results. No allowance will be made to the Contractor for additional cement required.

The minimum strength of concrete developed by concrete test specimens made and tested in accordance with the requirements of the A. S. T. M. serial designation C-31-27 shall be seventeen hundred (1700) lbs. per sq. in. at the age of 7 days and three thousand (3,000) lbs. per sq. in. at age of twenty-eight (28) days.

53.29. **Mixing Concrete:** Concrete shall be mixed thoroughly in a batch mixer of approved type for a period of not less than (1) minute after all the materials are in the drum, and during this period the drum shall make not less than fourteen (14) nor more than twenty (20) revolutions per minute. The mixer shall be equipped with an attachment for automatically timing each batch of concrete so that all the materials will be mixed together for the minimum time required. The timing device shall consist of an automatic arrangement for locking the discharge chute or it shall consist of a device which will warn the operator when all the materials have been mixed together the required period. In case the timing or locking device becomes temporarily inoperative, the Contractor shall immediately place before the mixer operator a clock or watch having a second hand which shall only be used until the timing device can be repaired or replaced. The entire contents shall be removed from the drum before the materials are placed therein for the succeeding batch.

53.30. **Hand Mixing:** When permitted, hand mixing may be done only on a water-tight wood or metal surface of suitable size. The cement and fine aggregate shall be mixed without the addition of water until a mixture of uniform color is produced. The coarse aggregate shall be spread to a depth of approximately eight (8) inches and wetted, the mixture of cement and fine aggregate spread over it, and the whole turned not less than four (4) times. Hand-mixed batches shall not exceed one-half (½) of a cubic yard.

53.31. **Placing Concrete:** Concrete shall be placed only on a subgrade prepared, compacted, tested, etc., as specified in Section 18 of these Specifications. Concrete shall be placed only on a moist subgrade which has been thoroughly watered on the previous evening for a length equal to the next day's work. The subgrade shall be prepared true to lines and grades shown on typical cross-section, at least three hundred (300) feet ahead of mixer. If the operation of hauling and delivering materials to the mixer causes a distortion of or destroys the previously prepared subgrade, the Contractor will be required to plank the same for a distance of one hundred (100) feet ahead of the mixer.

Before any concrete may be placed, each section of the subgrade must be re-checked with an approved "subgrade tester" and the section approved by the Engineer or his authorized representative; this operation being continued as the work progresses. The "subgrade tester" shall be of a tooth and continuous steel blade type, operating on the forms at the discharge end of the mixer at all times.

The operation of transporting the concrete from the mixer drum to its proper place in the road and spreading and putting it into place shall be so conducted as not to cause or permit any separation or segregation of the concrete. Concrete shall be distributed to the required depth by shoveling, or other approved means, and for the entire width of the slab as a continuous operation between joints without the use of intermediate forms or bulkheads. Where a center longitudinal contraction joint is being constructed in the pavement the first batch of concrete must be discharged and distributed along said center joint and the succeeding batches alternately on each side thereof. The concreting must be maintained approximately at right angles to the center line of the road. Discharging or depositing concrete directly against the forms will not be permitted. The concrete must be placed against the forms by shoveling and shall be thoroughly spaded along the inside of the form. Rakes shall not be used in handling concrete and the workmen must not be allowed to walk in the green concrete with boots which are carrying or are coated with loose foreign material of any kind.

In case of a breakdown, concrete shall be mixed by hand to complete the section or an intermediate transverse joint placed at the point of stopping work. No section of pavement shall be constructed less than ten (10) feet in length. Any concrete in excess of that needed to complete a section at the stopping of work shall not be used in the work.

53.32. **Metal Center Strip:** Where required by the plans the concrete pavement shall be built with a longitudinal joint in the center of the pavement. This joint shall be made by installing a center strip conforming to design called for on plans. The center strip shall be firmly held in place by steel pins or channel stakes driven into the ground. The center strip shall be furnished in sections not less than ten (10) feet and not more than fifteen (15) feet in length. Adjoining strips shall be rigidly connected either by an interlocking device in the strip itself or by lapping the strips at least two (2) inches and driving pins through matched holes in the adjoining pieces. The center strip shall be punched with holes for the passing through of transverse dowel bars. Transverse dowel bars across the center joint shall be of size length and spacing as called for on plans and shall be placed through the holes in the center strip provided for them. These bars shall be deformed steel bars meeting the specifications of steel reinforcing bars and shall be held in place during the pouring of the concrete by suitable metal chairs. Chairs will be required for each dowel bar.

53.33. **Transverse Joints:** Transverse joints shall be formed at right angles to the center line of the pavement and perpendicular to the surface at the end of each day's work, whenever the mixer is stopped for more than thirty (30) minutes, and at such intervals as may be shown on the plans. Details of joints and filler shall conform to details shown on the plans.

(a) **Poured Joints:** In general joints shall be not less than one-half (½) inch or more than three fourths (¾) inch in width or as shown on the plans. They shall be formed by a suitable metal bulkhead placed before the concrete is deposited. After the concrete has set sufficiently to permit the bulkhead to be removed without injury to the adjacent concrete, the bulkhead shall be removed and the joint protected from injury until the concrete has become dry. If dowels extend thru the joint care shall be taken to clean out concrete under and around the dowels. After the concrete is dry the joint shall be cleaned out down to the subgrade and the joint shall be filled with approved joint filler as specified in Paragraph 53.18 heated to such temperature that it will penetrate the full width and depth of the joint. A sufficient amount of filler shall be used to fill the joint and project about one-fourth (¼) inch above the surface of the pavement, but shall not spread more than one (1) inch on either side of the joint.

(b) **Premolded Joints:** If a premolded fabricated joint is to be used it shall be formed during the placing of the concrete by securely staking a metal bulkhead accurately in place at the joint location against which prepared joint filler shall be fastened before the concrete is deposited against it. The bulkhead shall be cut to the exact cross-section of the pavement one-quarter (¼) inch less than the depth of the pavement and one-half (½) inch less than the width of pavement. When the concrete has been placed on both sides of the joint, and the finishing machine worked over the same, the bulkhead shall be slowly and carefully removed, leaving the prepared filler in place. While the bulkhead is being removed concrete shall be carefully spaded and additional freshly mixed concrete worked into any depressions left by the removal of the bulkhead. After the pavement has been finished over the joint, the joint shall be opened and edged with a tool having a one-half (½) inch radius, and the filler must be exposed for its full width across the entire roadway.

53.34. **Machine Compaction:** After the concrete has been deposited and spread, it shall be struck off in such a manner that the crown elevation shall be from one-quarter (¼) of an inch to three-quarters (¾) of an inch, as may be required, higher than the finished pavement and then compacted mechanically with a power machine, approved by the Engineer, until all voids are removed and the concrete thoroughly compacted. The mechanical compacting machine or finishing machine shall go over each area of pavement as many times as is required to give the proper compaction, and at such intervals as will give the desired results. The finishing machine shall be kept in repair and first class working order at all times and shall be in charge of, and operated by, a skilled operator.

53.35. **Hand Compaction:** For emergency use in case of breakdown and on special sections, hand tamping may be substituted, if special permission in writing, is obtained from the Engineer. For this purpose a properly constructed strike templet, made of 4 inches by 10 inches lumber and two (2) feet longer than the width of the pavement, a tamping templet, made of 4 inches by 10 inches lumber and two (2) feet longer than the width of the pavement shall be maintained at the work, at all times, by the Contractor. The edge of the strike templet shall be cut to shape that when used with a zig-zag movement across the pavement it will strike off and leave the green concrete three-eighths (3/8) inches or such height as directed by the Engineer above the elevation on the finished surface. The edge of the tamp templet shall be cut to form and have a three-eighths (3/8) inch steel surface fastened thereon. After the concrete has been deposited, it shall be leveled off with the strike templet as herein provided, and throughly compacted with the tamping templet. Tamping shall be repeated until the required compaction is secured.

53.36. **Finishing:** Immediately after the final compacting operation has been completed, all surplus water, laitance or inert material shall be worked off by one of the following methods:

(1) The entire surface of the pavement shall be scraped or squeeged with a straight edge having a length of not less than ten (10) feet nor more than fourteen (14) feet. This straight edge shall be operated

from parallel bridges resting on the side forms. This straight edge shall be constructed so that the cross-section shall have the form of an inverted "T." The horizontal or base portion shall be a two by six (2 x 6) inch plank of the proper length; the vertical portion shall be a two by eight (2 x 8) inch plank. The two planks shall be securely fastened and braced to each other. Suitable handles shall be provided for the smooth and easy manipulation from the bridges as specified.

The scraping, squeegeeing, or floating shall be accomplished by drawing the straight edge from the crown of the pavement to each side in such manner that all laitance, surplus water and inert material shall be removed from the surface. At each operation of the straight edge there shall be one-half (½) lap longitudinally.

(2) The surface of the pavement shall be rolled with a smooth roller, not less than six (6) feet in length operated by means of ropes or long handles. The roller shall be operated slowly in a transverse direction from one edge of the pavement to the other and back again over the same area. A one-half (½) lap longitudinally, shall then be made, taking great care not to mar or displace the concrete, and the rolling continued in the same manner until the entire surface has been rolled.

For the purpose of removing any marks that may have been made by the use of the longitudinal float or roller or for the purpose of repairing any discrepancies or irregularities that may appear in the surface of the pavement, the Contractor shall maintain at the work two (2) wooden floats having handles at least ten (10) feet long. The float portion shall be of dressed one (1) inch lumber, three (3) feet long by six (6) inches wide.

Immediately after treating the pavement with the longitudinal float or roller as above specified, the surface shall be belted once, operating the belt with a combined cross-wise and longitudinal motion. Care shall be taken not to displace any of the concrete nor mar the surface. The belt used shall be of canvas or canvas-rubber composition from two to four ply and shall have a width of not less than six (6) inches and a length of at least two (2) feet more than the width of the pavement. The ends of the belt shall be fastened to suitable handles to permit its easy, smooth and proper manipulation. The belt shall be cleaned after each day's run and shall be oiled as required by the Engineer.

Immediately after the surface of the pavement has been given the preliminary belting it shall be tested at all points by means of ten (10) foot straight-edges applied longitudinally to the surface of the pavement and lapped one-half (½) its length longitudinally as the testing proceeds. Any variations from the required surface, shall be corrected at once.

The straight edges shall be furnished by the Contractor and maintained clean and free from warp and in perfect condition at the work at all times. The straight edges shall be swung from handles at least three (3) feet longer than one-half of the width of the pavement. All variations from the grade or cross-section desired shall be eliminated by means of the long handle wooden float or other suitable means. High spots shall be cut down and where necessary, additional concrete added to raise depressions to proper surface. If necessary the surface shall be treated again with the long handled float until satisfactory surface finish has been obtained.

When the surface of the concrete is free from water, and just before the concrete obtains its initial set, it shall be given a final belting to produce a uniform finish. The final belting, using a belt of the dimensions and composition previously described, shall be of short, transverse strokes, having a sweeping longitudinal motion. Badly worn belts shall be discarded and new ones used.

53.37. **Testing Surface:** The finished pavement surface shall show no deviation from the general surface in excess of one-sixteenth (1/16) inch per foot, as measured in the following manner: a ten (10) foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depressions and ordinates measured from the face of the straight edge to the surface of the pavement shall not exceed one-sixteenth (1/16) inch for each foot in distance from nearest point of contact.

53.38. **Uneven Surface to be Remedied:** Should any variation appear amounting to one-sixteenth (1/16) of an inch per foot or over, the Contractor shall take such means as will be effective to produce a smooth surface conforming to the required cross-section. If any appreciable amount of variation over one-sixteenth (1/16) of an inch per foot as determined in Par. 53.37 occurs in the finished pavement, the Contractor will be required to remove the affected portion of slab and replace it with new concrete at his expense, or he will at the option of the Engineer, be required to use a grinding machine to bring the surface to the required cross-section. Any section of the pavement removed and replaced shall be not less than ten (10) feet in length and of the full width of the pavement on one-half this width if a center-joint is used as may be required by the Engineer. In case the State is furnishing the cement for the work, all cement used to replace defective work shall be charged to the Contractor and taken from such sums as may be due the Contractor by the State.

53.39. **PROTECTION AND CURING CEMENT CONCRETE PAVEMENT**

53.40. **Protection of Concrete:** Immediately after finishing, the concrete shall be covered with wet burlap placed directly on the concrete when same is sufficiently hardened to admit such placing without marring the surface. This covering shall be kept thoroughly wet until removed. When the concrete has hardened sufficiently and not later than 10:00 A. M. the following day the covering shall be removed and the specified curing process immediately begun.

Immediately after the forms are removed a sufficient amount of earth shoulder shall be placed against the concrete to protect the edges and prevent any undermining of the pavement.

53.41. During cold weather when the air temperature may be expected to drop below thirty-five (35) degrees F. a sufficient supply of straw, or other material suitable for covering, shall be provided along the line of the work and any time when the air temperature may reasonably be expected to reach the freezing point during the day or night, the material specified herein shall be spread over the surface of the concrete to a sufficient depth to prevent freezing until the concrete has been deposited for at least five (5) days. All concrete which has not been properly protected as above specified and concrete which may have become damaged by frost shall be replaced at the Contractor's expense upon written notice from the Engineer.

53.42. Suitable barricades must be erected and maintained by the Contractor to exclude traffic during protection and curing for the duration of time specified below.

53.43. Satisfactory precautions shall be taken to exclude foot traffic for a period of not less than three (3) days, and vehicular traffic for a period of not less than twenty-one (21) days after concrete is finished.

If in the opinion of the Engineer the surface is in an acceptable condition, at the expiration of the twenty-one day period, the pavement may then be opened to traffic.

53.44. **Curing:** One of the following methods shall be used:

(a) **Straw or Earth Method:** Immediately after removing burlap it shall be replaced with a covering of straw not less than four (4) inches thick, sand, or earth not less than one and one-half (1½) inches thick, or other satisfactory material. Such covering shall be kept wet for a period of ten (10) days and maintained in place for eighteen (18) days, at which time it shall then be removed and the concrete swept clean.

(b) **Ponding Method:** The surface of the concrete shall be kept covered with water for ten (10) days in accordance with the usual practice for the ponding method. The surface shall be swept clean at the end of eighteen (18) days. This method may be used if conditions permit, with the Engineer's approval.

(c) **Calcium Chloride Method:** The surface shall be uniformly covered with Calcium Chloride as specified in Paragraph 53.20 (a), applied at a rate of not less than two (2) pounds and not more than two and one-half (2½) pounds per square yard of pavement, spread with a suitable spreader in order that a uniform distribution may be obtained. Spreading by means of shovels and brooms will not be permitted except when curing small areas such as patching jobs.

The burlap shall not be removed nor the Calcium Chloride applied until a period of at least sixteen (16) hours has elapsed after the pavement has been laid, and not later than ten o'clock A. M. of the day following the placing of the concrete. The concrete must not be exposed to the hot sun without Calcium Chloride after this point has been reached. Should sections be insufficiently covered additional application should be made over such sections.

In cold weather the Calcium Chloride cannot be applied as soon as in hot, dry weather. It sometimes requires as much as thirty-six (36) or forty-eight (48) hours after the placing of the concrete to reach the proper set. In any case the time of removal of burlap and beginning of curing operation shall be regulated by the Engineer.

The Calcium Chloride shall not be applied during rain, and if rain falls in sufficient quantity to wash the Clacium Chloride from the surface within three (3) hours after its application, a new application must be made, in similar manner as first application.

(d) **Silicate of Soda Method:** Wet burlap shall be used to cover the concrete after finishing and shall remain in place until the concrete has hardened sufficiently and not less than sixteen (16) hours after the pavement has been laid. The burlap shall be removed a sufficient time before the application of Sodium Silicate to allow the evaporation of surface water, the presence of which would cause undesirable dilution of the Sodium Silicate when applied.

Not later than ten (10) o'clock A. M. of the day following the placing of the concrete, Sodium Silicate diluted with water as specified in Paragraph 53.20 (b) shall be poured, and swept with brooms or brushed uniformily over the surface of the concrete. One pound of the original Silicate of Soda (42.5 Be) weighs approximately eleven and three-quarters (11¾) lbs. per gallon then each gallon of this original Sodium Silicate should cover approximately eleven and three-quarters (11¾) square yards of surface.

No second treatment of Sodium Silicate is needed if rain occurs after it has been down over six (6) hours. If rain occurs before this time, the newly covered section will be treated with a one to (1) one (1) mixture of water and Sodium Silicate. Should sections be insufficiently covered additional applications shall be made over such sections.

53.45. **Checking Quantity of Cement Used:** In the event that, under any circumstances, the actual amount of cement used is less than ninety-six (96) per cent of the calculated amount necessary for each day's run, said calculated amount to be based on field test, the Contractor will be required to make the necessary adjustment in his method of construction in order to properly utilize the required amount of cement, and, furthermore, the Contractor may be required to remove and replace, entirely at his own expense, that unit of pavement length wherein insufficient cement was used.

53.46. **Deduction for Deficient Thickness:** After the concrete pavement has been completed cores shall be bored from the pavement to determine the thickness. The average thickness of the pavement shall be determined from the lengths of the cores. The borings shall be taken at least every thousand feet (1000′) and as much oftener as the conditions warrant. The Contractor shall have the privilege of requiring additional borings where a deficiency in thickness is found but the cost of such additional borings shall be paid by the Contractor.

No payment shall be made for any pavement whose thickness, as determined by core lengths is one-half (½) inch, or more than one-half (½) inch, less than the thickness shown on the plans.

In case the average thickness of the pavement within the limits of the bore and one-half (½) inch tolerance, as determined by core lengths, is less than the required thickness a reduction shall be made in the price paid for the pavement. In computing the average thickness all measurements which are more than one-half (½) inch greater than the required thickness shall be counted as the specified thickness plus one-half (½) inch. The price allowed for the pavement of less than the required thickness shall bear the ratio to the contract price as the average thickness bears to the required thickness. No increase in price will be allowed for excess thickness.

The area of the pavement to be completely deducted, in case of short cores, shall be the full width of the pavement for the sum of the distances from the short core to the borings on each side which measure up to the required tolerated thickness.

53.47. **Field Laboratory:** The Contractor shall provide a field laboratory in which to house and use the testing equipment, said laboratory to be not less than ten (10) feet wide, twelve (12) feet long and seven (7) feet high, floored, containing not less than two (2) windows and a work-bench with necessary drawers. This laboratory is to be maintained to be used exclusively for testing purposes by the Engineer or Inspector.

53.48. **Basis of Payment:** The item will be paid for at the contract unit price per square yard for "Plain Cement Concrete Pavement" complete in place which price will be full compensation for all materials, equipment, tools, labor, and incidentals necessary to complete the item, except that steel reinforcement will be paid for as a separate item.

Payment will be made under

Item No. 56, Plain Cement Concrete Pavement (square yard).

SECTION 54

REINFORCED CEMENT CONCRETE PAVEMENT

54.01. **Description:** This item shall consist of cement concrete, constructed in accordance with specification for "Plain Cement Concrete Pavement," except that the concrete shall be reinforced with steel fabric or bars in accordance with these Specifications, and of the form and dimensions shown on the plans.

MATERIALS

54.02. Materials shall conform to the requirements set forth in Section 53 "Plain Cement Concrete Pavement" for the several items entering into the construction with the addition of the following:

54.03. (a) **Bar Reinforcement:** Reinforcement metal shall be manufactured in accordance with and shall in all respects fulfill the physical and chemical requirements of the American Society for Testing Materials, Standard Specifications for Billet Steel Reinforcement Bars serial designation A-15-14 with any subsequent amendments and additions thereto adopted by the Society.

Unless otherwise designated upon the plans, all bar reinforcement shall be of open hearth steel of the structural intermediate grade.

When deformed bars are specified, the form of the bar used must be such as to provide a net section at all points equivalent to bars that of a plain square or round bar of equal nominal size. Twisted bars will be used only by permission of the engineer.

For dowel bars in pavements reinforcement material may be of rail steel reinforcement bars, meeting the requirements of the specifications of the American Society for Testing Materials, serial designation A-16-14.

54.04. (b) **Mesh Reinforcement:** Reinforcing materials shall consist of a steel fabric manufactured from steel meeting the requirements of the American Society for Testing Materials, serial designation A-82-21-T.

Reinforcement shall be free from excessive rust, scale or coating of any character which will impair its bond with the concrete. Fabric reinforcement shall consist of members rigidly attached to all joints, or joints of intersection and shall have an effective weight of approximately forty-four (44) pounds per one hundred (100) square feet. The spacing of the main members of the fabric shall not be more than six (6) inches nor less than four (4) inches. Tie members to be spaced not more than twelve (12) inches nor less than eight (8) inches. The effective cross sectional area of the main members shall not be less than 0.10 sq. in. per foot of fabric. The effective cross sectional area of the tie members shall not be less than twenty-five hundred (.025) sq. in. per foot of the fabric. Unless otherwise noted on plans reinforcing conforming to the above specifications will be the standard.

CONSTRUCTION METHODS

54.05. Construction Methods shall conform to specifications for "Plain Cement Concrete Pavement," Section 53, with the following paragraphs additional.

54.06. **Placing Reinforcement:** Reinforcement of bars or mesh shall be placed as shown on the plans. In general, mesh, reinforcement shall be placed at right angles to the axis and two (2) inches below the surface of the pavement, and it shall extend to within two (2) inches of the ends and sides of the slabs. Adjacent sheets of fabric shall be lapped not less than six (6) inches when the lap is made at right angles to the center line of pavement.

54.07. **Basis of Payment:** This item will be paid for at the contract unit price per square yard for "Reinforced Cement Concrete Pavement," complete in place, which price will be full compensation for furnishing, hauling, and placing all materials, for all equipment, tools, labor and incidentals necessary to complete the item.

Payment will be made under
Item No. 57, Reinforced Cement Concrete Pavement (square yard).

SECTION 55

CEMENT CONCRETE PAVING ON BRIDGES

55.01 **Description:** This item shall consist of a Cement Concrete Pavement or wearing surface of the type and thickness specified, prepared and placed upon the completed floor of the structure to the grade and contour indicated on the plans or designated by the Engineer in accordance with these Specifications.

MATERIALS

55.02. **Cement and Water:** The cement and water used shall conform to the requirements specified under "Plain Cement Concrete Pavement" Section 53.

55.03. **Fine Aggregates:** The quality and grading of the fine aggregates shall meet the requirements specified in Paragraphs 53.09-53.10 of Section 53 "Plain Cement Concrete Pavement." The fine aggregate shall be tested in combination with the coarse aggregate and cement with which it is to be used in the proportion of a 1:2:3 mixture including water and shall show a minimum compressive strength at the end of seven (7) days of 1700 pounds per square inch and at the end of twenty-eight (28) days of 3000 pound per square inch. Upon failure to meet the requirements the proportion of cement, fine aggregate, coarse aggregate and water shall be changed in such a way as to produce the specified strength, and the Contractor shall receive no extra compensation for such change.

55.04 **Coarse Aggregates:** The quality of coarse aggregate shall meet the requirments specified in Paragraphs 53.12 to 53.17, inclusive, of Section 53 "Plain Cement Concrete Pavement," except that the coarse aggregate shall comply with the grading requirements for Class "D" concrete under "Bridges", the maximum size being one and one-half (1½) inches.

55.06. **Joint Filler:** Shall conform to the requirements specified under Paragraph 53.17, Section 53, "Plain Cement Concrete Pavement."

55.07. **Premolded Expansion Joint:** Shall conform to the requirements specified in Section 53, "Plain Cement Concrete Pavement," Paragraph 53.19.

CONSTRUCTION METHODS

55.08. The paving shall be composed of one part of Portland Cement, and five parts of fine and coarse aggregate to approximate a 1:2:3 mixture, mixed in accordance with these Specifications.

Coarse aggregate of maximum size one and one-half (1½) inches shall be used, otherwise requirements for Class "D" concrete under "Bridges" will apply.

55.09. **Placing:** The bridge slab shall be thoroughly cleaned and when dry the entire surface of the slab shall be painted with hot tar allowing three tenths (3/10) gallons per square yard of surface, are being exercised to keep the tar off curb and other exposed parts of the bridge.

After mixing, the concrete shall be deposited to the depth required, on the bridge slab as prepared. The depositing shall be a continuous operation and for the entire width of the slab.

Transverse expansion joints shall be provided at right angles to the roadway, over all expansion joints between the decks, the widths of joints to be the same as between the decks. Longitudinal expansion joints, one-half (½) inch in width, shall be provided parallel to and against both curbs for the entire length of the bridge. The expansion joint material shall be bituminous premoulded joint material meeting the requirements of Paragraph 53:19 of these Specifications.

55.10. **Finishing Concrete:** The surfacing of the concrete shall be struck off by means of a steel template of approved section, weighing not less than two hundred (200) pounds for a length of eighteen (18) feet, which has a crown greater than one-quarter (¼) inch, or more if required by the Engineer, than the crown specified in the finished surface, to insure that the crown required for the finished surface is obtained. The template shall be rolled to the required cross-section and have sufficient strength to retain its shape under all working conditions. This template shall be moved with a longitudinal and cross-wise motion, moving always in the direction in which the work is progressing. When the template reaches within three (3) feet of a transverse joint where the joint filler projects above the established grade, it shall be lifted to the joint and the pavement struck by moving the template away from the joint and all excess concrete shall be removed.

After the concrete has been struck off, it shall be tamped by means of a steel template, or steel shod wooden template of approved section, weighing approximately eight (8) pounds per linear foot. shall be shaped to the cross-section of the pavement and have sufficient strength to retain its shape under all working conditions. After the concrete has been struck off and tamped it shall be finished either by using a hand roller and belt, or by using a belt alone. If the Contractor elects to use the roller, the surface shall be rolled with an approved metal hand roller having a smooth, even surface approximately six (6) feet in length, not less than eight (8) nor more than twelve (12) inches in diameter and weighing not more than one hundred (100) pounds. This roller shall have a handle at least two (2) feet longer than the width of the pavement. The roller shall pass from one edge of the pavement to the other in one operation, and the rolling shall continue until free water ceases to appear on the surface.

After the concrete has been tamped, or tamped and rolled, the surface shall be finished by using a belt of wood, or canvas, or rubber not less than eight (8) nor more than twelve (12) inches in width. These belts shall be worked with a longitudinal and cross-wise motion as described for the steel template. Care shall be observed in the use of the belt not to permit the edges to dig into the surface of the concrete or work the crown out of the pavement. When approved in writing by the Engineer, the belting may be omitted and the pavement dragged with a three-quarter (¾) inch smooth rubber surface hose until the free water has been pulled off. The hose length shall be at least twice the width of the pavement. The final dragging with the hose shall leave the surface of the pavement free from irregularities and uniformly smooth. The concrete adjacent to the transverse joint shall be finished with a split wood float which will insure finishing both sides to the same grade, after which the edges of the concrete at the joint shall be rounded with an approved edging tool to a radius of one-half (½) of an inch and the sides of the slabs to a radius of approximately three-quarters (¾) of an inch. The finishing of the joint shall be done from a bridge which shall not rest on the concrete at any point.

55.11. **Testing Surface:** The finished pavement surface shall show no deviation from the general surface in excess of one-sixteenth (1/16) inch per foot, as measured in the following manner: a ten (10) foot straight edge shall be placed parallel to the center line of the roadway, so as to bridge any depressions and ordinates measured from the face of the straight edge to the surface of the pavement shall not exceed one-sixteenth (1/16) inch for each foot in distance from nearest point of contact. Should any variation appear amounting to one-sixteenth (1/16) of an inch or over, the Contractor shall take such means as will be effective to produce a smooth surface conforming to the required cross-section. If in the opinion of the Engineer any appreciable amount of variation over one-sixteenth (1/16) of an inch occurs in the finished pavement, the Contractor will be required to remove the affected portion of slab and replace it with new concrete at his expense, or he will be required to bush-hammer the surface to the required cross-section at the option of the Engineer. In case the State furnishes the cement for the work, all cement used to replace defective work shall be charged to the Contractor and taken from such sums as may be due the Contractor by the State.

55.12. Paving shall be protected and cured in accordance with Specifications set forth under "Plain Cement Concrete Pavement" Section 53.

55.13 **Bases of Payment:** This item will be paid for at the contract price per square yard for "Cement Concrete Pavement on Bridges" which shall be full compensation for all materials, equipment, forms, expansion material, paint coat, labor and incidentals necessary to complete the item.

Payment will be made under

Item No. 58, Cement Concrete Pavement on Bridges (square yard).

SECTION 56

BITUMINOUS WEARING SURFACES FOR BRIDGES

56.01. **Description:** These items shall consist of a bituminous pavement or wearing surface of the type and thickness specified, prepared and placed upon the completed floor of the structure to the grade and contour indicated on the plans or designated by the Engineer in accordance with these Specifications and in conformity with the requirements for the other items of the work.

MATERIALS

56.02. **Materials:** Materials shall conform to the requirements set forth for the Standard item for the specified type of surface shown elsewhere in these Specifications.

CONSTRUCTION METHODS

56.03. **General:** The method of construction shall be, in so far as they are applicable, in accordance with the Specifications for the Standard item for the specified type of surface.

56.04. **Wood Sub-Floor:** Before placing the wearing surface, all parts of the sub-floor shall be securely fastened to prevent vibration and all sharp corners, projections or irregularities in the surface shall be removed. Wood which is worn or which contains defects which may be injurious to the wearing surface shall be removed and renewed. Any openings in the floor shall be completely sealed by caulking with oakum, or by other suitable means. All dust, dirt, debris, or foreign material on or adhering to the surface to be treated shall be removed by sweeping with stiff brooms and if necessary the surface shall be flushed with water. If water is used, the sub-floor shall be allowed to become thoroughly dry and then swept with stiff brooms before applying the prime coat.

Any excess of free creosote oil upon the surface of the floor shall be removed with gasoline before applying the priming coat. After cleaning, no traffic shall be permitted on the floor until completion of the wearing surface.

56.05 **Concrete Sub-Floor:** The requirements as to cleanliness and traffic, as specified above for wood sub-floors, shall also apply to concrete sub-floors. Irregularities in the surface such as might project into or injure the wearing surface, shall be removed.

56.06. **Prime Coat:** After the sub-floor has been prepared as above specified and is thoroughly dry, the surface which is to receive the asphalt shall be covered with a prime or paint coat of asphalt cement cut back consisting of thirty-five (35) per cent gasoline and sixty-five (65) per cent of asphaltic cement. This shall be applied only far enough in advance of the raking to give the cut-back gasoline time to evaporate and yet leave the prime coat sticky.

The asphalt paint shall be of the approximate consistency of thin house paint and shall be applied as thinly as possible, using care to prevent any puddles collecting in crevices, joints or depressions.

56.07. **Basis of Payment:** This item will be paid for at the contract price per square yard for the type specified complete in place which price shall be full compensation for all materials, equipment, tools, labor and incidentals necessary to complete the item.

SECTION 57

BITUMINOUS MAT COAT

57.01. **Description:** A hot bituminous mat coat shall be applied on the bridge floors as specified on the plans.

MATERIALS

57.02. **Stone or Slag Screenings:** Shall consist of angular fragments of clean, hard, tough, durable material of uniform quality throughout, free from disintegrated material, dirt or other objectionable matter and well graded as follows:

Passing ½ inch screen	100%
Retained ¼ inch screen	100%

57.03. **Refined Tar:** Shall be homogeneous, free from water and shall not foam when heated to 347 degrees F. and shall meet the following requirements:

(a) Specific gravity at 77 degrees F., 1.130 to 1.250.
(b) Float test at 90 degrees F., 60 to 150 seconds.
(c) Distillate to 338 degrees F., not over 1.0%.
(d) Distillate to 518 degrees F., not over 15.0%.
(e) Distillate to 572 degrees F., not over 25.0%.
(f) Total bitumen soluble in CS_2, 85 to 100%.

CONSTRUCTION METHODS

57.04. **Laying:** The surface of the roadway shall be thoroughly cleaned of all dust, dirt or loose and scaly particles. When the surface is dry, the bituminous material, heated to a temperature of not less than two hundred (200) degrees Fahrenheit nor more than two hundred and fifty (250) degrees Fahrenheit shall be spread uniformly over the surface, using one-half (½) gallon per square yard of surface.

The stone screening or slag, shall be evenly and thoroughly distributed over the entire surface, after the bituminous material has been spread thereon, the bituminous material being still hot. The entire surface shall then be thoroughly rolled with an approved five (5) ton roller.

If the bituminous material shows through, additional covering material shall be applied and the entire surface rolled again. Successive application of bituminous material and covering shall be made until the desired thickness of mat coat has been built up.

All joints, corners or depressions shall be filled with the hot bituminous material and covered with sand.

57.05. **Bases of Payment:** This item will be paid for at the contract unit price per square yard for "Bituminous Mat Coat" complete in place which price shall be full compensation for all materials, equipment, tools, labor, and other things necessary to complete the item.

Payment will be made under
Item No. 59, Bituminous Mat Coat (square yard).

PAMPHLET "G"

GEORGIA STATE HIGHWAY DEPARTMENT

STANDARD SPECIFICATIONS

1928

DIVISION II

STRUCTURES

SECTION 67

CONCRETE STRUCTURES

67.01. **General.** Concrete Masonry referred to in these Specifications shall consist of a mixture of Portland cement, aggregate and water mixed in such proportions and handled in such a manner as to obtain the specified quality of finished masonry.

MATERIALS

CEMENT

67.02. **Portland Cement:** All cement used in the work shall conform to the requirements of the "Standard Specifications and Tests for Portland Cement" adopted by the American Society for Testing Materials—serial designation C-9-26, as modified and amended from time to time by the American Association of State Highway Officials.

Each shipment or lot of cement used on the work shall be sampled and tested in accordance with the amended "Standard Specifications and Tests" above designated. All cement used shall be shipped in cotton cloth bags.

67.03. **Storage of Cement:** The Contractor shall provide suitable means for storing and protecting the cement against dampness. When cement is furnished by the State, any that has been damaged because of the failure of the Contractor to provide suitable storage shall be paid for by the Contractor. Different brands or grades of cement shall be stored separately.

67.04. **Damaged Cement:** Bags of cement, which for any reason have become partially set, or which contain lumps or caked cement, shall be rejected. In no instance will any portion of a bag of damaged cement, or a bag containing lumps of caked cement, be used.

Cement salvaged from discarded or used sacks will not be permitted to be used.

Cement shall not be used while its temperature is more than 100 degrees Fahrenheit.

67.05. **Ordering Excess Cement:** The Contractor shall be held responsible for ordering the correct amount of cement, and if the cement is being furnished by the State, the Contractor shall be charged the net price paid by the State for the Excess cement after the completion of any contract, which excess shall become the property of the Contractor.

67.06. **Mixing Different Cements:** Different brands of cements, even if tested and approved, shall not be mixed during use, or used alternately, in any one class of construction.

HYDRATED LIME

67.07. Hydrated lime shall be used only when required by Special Provision or ordered by the Engineer. When so used the material shall conform to the requirements of the "Specifications for Hydrated Lime" of the American Society for Testing Materials, serial designation C-6-24.

WATER

67.08. The water used in mortar or concrete shall be subject to the approval of the Engineer, and shall be fresh, reasonably clear, free from oil, acid, salt, strong alkali or vegetable matter. Tests of water shall be made in accordance with the requirements of United States Department of Agriculture, Bulletin 1216 of May 1924 with subsequent revisions.

FINE AGGREGATES

67.09. (a) **General:** Fine aggregate shall consist of sand, stone screenings, or other inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable uncoated grains, free from injurious amounts of clay lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances.

67.10. **Grading:** Stone screenings either alone or in combination with sand, shall not be used as fine aggregate except when approved by the Engineer.

Fine aggregate shall preferably be graded from fine to coarse with the coarser particles predominating within the following limits:

Passing No. 4 sieve	100%
Passing No. 20 sieve	50 to 75%
Passing No. 50 sieve, not more than	30%
Passing No. 50 sieve, not less than	5%
Passing No. 100 sieve, not more than	5%
Weight removed by elutriation test, not more than	3%

Sieves shall conform to the requirements specified in the "Standard Method of Test for Sieve Analysis of Aggregates for Concrete," serial designation C-41-24-T of the American Society for Testing Materials.

67.11. **Strength in Concrete:** The fine aggregate shall be tested in combination with the coarse aggregate and the cement with which it is to be used and in the proportions, including water, in which they are to be used on the work, in accordance with the requirements specified in Paragraph 67.14. In case the test provided in Paragraph 67.14 shows the strengths specified therein, the fine aggregate shall be considered acceptable.

67.12. **Mortar Strength:** With the approval and consent of the Engineer, on less important work, the following requirements may be substituted:

(a) Mortar briquettes, cylinders or prisms, consisting of one part by weight of Portland cement and three parts by weight of fine aggregate, mixed and tested in accordance with methods described in the Standard Specifications and test for Portland Cement, serial designation C-9-26 of the American Society for Testing Materials, shall show a tensile or compressive strength at the age of 7 and 28 days not less than that of 1:3 Standard Ottawa sand and mortar of the same consistency made with the same cement.

(b) Upon failure to meet the requirements set forth in the foregoing paragraph, material for Class "A" concrete having a test ratio of 85% or above and material for Class "B" and "C" concrete having a test ratio of 75% or above, when compared with Standard Ottawa sand, may have the proportion of cement increased so as to produce 100% strength ratio for material to be used in Class "A" concrete and 90% strength ratio for material to be used in Class "B" and "C" Concrete. The exact proportions shall be determined by Laboratory tests. No extra compensation shall be allowed the Contractor for additional cement required.

(c) A mixture of sand and stone screenings, when permitted, in proportion of not over fifty (50) per cent stone screenings shall have a strength ratio of not less than 112 per cent when tested as outlined above.

67.13. **Organic Matter:** No fine aggregate showing a color darker than the standard color when tested in accordance with the Standard Method of Test for Organic Impurities in Sands for Concrete, serial designation C-40-22 of the American Society for Testing Materials shall be used unless the strength requirements of Paragraph 67.14 is fulfilled.

67.14. **Grade and Strength:** The grade of concrete required will generally be specified and shall meet the following minimum requirements as to compressive strength:

Class	Mixture	7 Day Test	28 Day Test
A	1-2 -4	1300 lbs. per sq. inch	2200 lbs. per sq. inch
B	1-2½-5	1000 lbs. per sq. inch	1700 lbs. per sq. inch
C	1-3 -6	900 lbs. per sq. inch	1500 lbs. per sq. inch
D	1-2 -3	1500 lbs. per sq. inch	2500 lbs. per sq. inch

The Concrete materials including cement, fine aggregate, coarse aggregate and water, mixed in the proportions in which they are to be used in the work, and tested in accordance with the standard methods of testing, shall at twenty-eight (28) days develop a strength of not less than that specified for the grade of concrete required. Upon failure to meet the requirements the proportion of cement, fine aggregate, coarse aggregate and water shall be changed in such way as to produce the specified strength, and the contractor shall receive no extra compensation for such change.

67.15. **Storage and Handling:** The method of storage and handling fine aggregate on the work shall be such as to avoid segregation of sizes, and the material becoming mixed with mud, dust or trash. When deemed necessary, the Engineer may order the use of platforms for the storage of fine aggregate.

COARSE AGGREGATES

67.16. **General:** The coarse aggregates for all classes of concrete shall consist of clean, hard, durable crushed stone, gravel or slag free from any coating of clay or slime. Material containing organic matter, thin elongated particles, clay or other deleterious substance, may be rejected by the Engineer without testing.

67.17. **Crushed Stone:** Crushed stone shall be obtained from clean tough, sound durable rock having a French Coefficient of wear of not less than six (6). The material shall be free from dust and an excess of flat and elongated pieces. Stone shall meet the accelerated soundness test described in U. S. Department of Agriculture, Bulletin No. 1216, of May 1924 with subsequent additions.

67.18. **Gravel:** Shall consist of clean, tough, durable stone of high resistance to abrasion, free of clay or coatings of any character. "Run of Bank" gravel or gravel which contains disintegrated or soft stone or shale, or excess of flat pieces shall not be used. The loss by abrasion shall not be more than twenty (20) per cent, when tested as described in U. S. Department of Agriculture Bulletin No. 1216.

67.19. **Slag:** Broken slag aggregate shall consist of clean, tough, durable pieces of copper or iron furnace slag, reasonably uniform in density and quality, non-glassy and free from thin elongated pieces, or any deleterious substance. The dry slag when shaken to refusal shall have a weight per cubic foot of not less than seventy-five (75) pounds, and a French coefficient of wear of not less than five and five-tenths (5.5).

67.20. **Methods of Tests:** Method of sampling and testing shall be in conformance with the practice recommended by the "Committee on Tests and Investigations" of the American Association of State Highway Officials or U. S. Department of Agriculture, Bulletin 1216.

67.21. **Grading:** Coarse aggregate shall be uniformly graded between the limits specified and shall meet the following requirements:

For Class "A" Concrete:

Passing a 1½-inch screen	95–100%
Passing a ¾-inch screen	35– 70%
Passing a ¼-inch screen	0– 5%

For Class "B" and "C" Concrete:

Passing a 2½-inch screen	100%
Passing a 2 -inch screen	80–100%
Passing a 1 -inch screen	40– 75%
Passing a ¼-inch screen	0– 5%

For Class "D" Concrete, the coarse aggregate shall be graded from particles passing a ¾-inch circular opening to particles retained on a ¼-inch screen as specified above.

67.22. **Abrasive Test:** For Class "A" and Class "D" concrete, the French coefficient shall not be less than six (6) when tested in accordance with Paragraph 67.20. Coarse aggregate for Class "B" and "C" concrete shall be subject to such tests as may be necessary to insure the selection of material suitable for the construction involved.

67.23. **Cyclopean Aggregate:** With the approval of the Engineer, boulders and large fragments of rock may be imbedded in Class "C" concrete used in footings. Each stone before being imbedded or placed shall be washed clean of all clay, dirt or other deleterious matter, and only sound, tough stone shall be used. No boulders shall be placed closer to each other, or to any part of the forms, than six (6) inches, and no stone shall be used the greatest dimensions of which is more than one-half (½) the least dimension of the footing. Each stone shall be thoroughly soaked before being placed.

67.24. **Storage and Handling:** The method of storage and handling aggregate on the work shall be such as to avoid segregation of sizes, and the material becoming mixed with mud, dust or trash. When deemed necessary, the Engineer may order the use of platforms for the storage of coarse aggregate. Stock piles shall be built in layers not exceeding three (3) feet in height. Mixing of different types of aggregates in one storage pile will not be permitted.

CONSTRUCTION METHODS

67.25. **Classification of Mixtures.** In general four classes of concrete will be specified having the following proportions of cement and aggreeages:

Class A concrete:	1 part of cement and 6 parts of fine and coarse aggregates, to approximate a 1:2:4 mixture.
Class B concrete:	1 part of cement and 7½ parts of fine and coarse aggregates, to approximate a 1:2½:5 mixture.
Class C concrete:	1 part of cement and 9 parts of fine and coarse aggregates to approximate a 1:3:6 mixture.
Class D concrete:	1 part of cement and 5 parts of fine and coarse aggregates to approximate a 1:2:3 mixture.

The ratio of fine and coarse aggregate shall be determined by the Engineer for the particular aggregates to be used, but the ratio of fine aggregate to cement shall not be more than the following:

Class A concrete:	1 part of cement to 2¼ parts of fine aggregate.
Class B concrete:	1 part of cement to 3 parts of fine aggregate.
Class C concrete:	1 part of cement to 3½ parts of fine aggregate.
Class D concrete:	1 part of cement to 2 parts of fine aggregate.

When the class of concrete is not indicated on the plans the following requirements will control:

1. For superstructure, arch rings, walls or other parts of a structure having a least dimension less than one (1) foot, and for all heavily reinforced concrete and concrete deposited under water, Class "A" concrete shall be used. Concrete deposited under water shall have ten per cent (10%) excess cement.

2. For substructures having a minimum thickness of at least one (1) foot, and in which all steel is embedded at least three (3) inches, Class "B" concrete shall be used.

3. For unreinforced footings, not deposited under water, Class "C" concrete shall be used.

4. For railing, rail posts, paving on bridges and other very thin sections Class "D" concrete shall be used, except that for paving the maximum size of the coarse aggregate may be one and one-half (1½) inches.

67.26. **Quality of Concrete.** In case the desired density or strength cannot be obtained from the concrete mixes previously described the Engineer may vary the relative proportions of fine and coarse aggregates or increase the amount of cement to obtain the desired results. No allowance will be made to the Contractor for additional cement required.

The minimum strength of concrete expressed in pounds per square inch developed by concrete test specimens made and tested in accordance with the requirements of the American Society for Testing Materials, Serial designation C-31-27 shall be as follows:

	Approx. Mix.	Age 7 days	Age 28 days
Class A concrete	1:2:4	1300	2200
Class B concrete	1:2½:5	1000	1700
Class C concrete	1:3:6	900	1500
Class D concrete	1:2:3	1500	2500

67.27. **Consistency.** The quantity of mixing water to be used shall be determined in each case by the Engineer and no changes shall be made without his consent. **In general a mixture shall be used which contains the minimum amount of water consistent with the required workability.**

In general, the consistency of concrete mixtures shall be such that:

1. The mortar clings to the coarse aggregate.

2. The concrete is not sufficiently fluid to segregate when transported to the place of deposit.

3. The concrete, when dropped directly from the discharge chute of the mixer, shall flatten out at the center of the pile but shall stand up and not flow at the edges.

4. The mortar shall show no free water when removed from the mixer.

5. The concrete shall settle into place when deposited in the forms and, when transported in metal chutes at an angle of thirty (30) degrees with the horizontal, it shall **slide** and not **flow** in place.

6. The upper layer of the set concrete shall show a cement film upon the surface but shall be free from laitance.

If the slump test is used for measuring the consistency of concrete, due consideration shall be given the character of the aggregates as affecting this test. The measured slump shall be as follows:

Mass Concrete	1½ to 3 inch slump.
Reinforced Concrete	
Beams and Thin Sections	3 to 5 inch slump.
Heavy Sections	2 to 4 inch slump.

67.28. **Measuring Materials.** Fine and coarse aggregates shall be measured separately by volume or by weight with an approved measuring device. The amount of aggregate used shall be the equivalent of loose volume measurement, correction being made for the water in the aggregate and for the bulking of damp sand.

The accurate measurement of each of the materials composing, and the production of a uniform mixture of the concrete are essential. The Contractor shall furnish and use approved timing devices, a water measuring and discharging device, also a batch measuring equipment which will give the exact amount of aggregate required by the Engineer.

The cement shall be measured as packed by the manufacturer, a sack containing not less than ninety-four (94) pounds being considered one cubic foot.

67.29. **Mixing Concrete. Machine Mixing.** Concrete shall be thoroughly mixed in a batch mixer of an approved type. Class A and Class D concrete shall be mixed for a period of not less than one and one-half (1½) minutes; Class B and Class C concrete shall be mixed for a period of not less than one (1) minute after all the materials are in the drum. During the time of mixing the drum shall revolve at the speed for which the machine was designed, but not less than fourteen (14) nor more than twenty (20) revolutions per minute. The entire contents of the drum shall be discharged before recharging.

The mixer shall be equipped with a device for accurately measuring the water and shall be equipped with a device for measuring the time of mixing or recording the number of revolutions of the drum for each batch.

Hand Mixing. Hand mixing shall not be permitted except with the specific permission of the Engineer in case of an emergency or on very small jobs. Hand mixing shall be done on water tight platforms. The sand shall be spread evenly over the platform and the cement spread upon it. The sand and cement shall then be thoroughly mixed while dry by means of shovels, until it has a uniform color, after which it shall be formed into a "crater" and water added to give it the proper consistency.

The coarse aggregate shall be thoroughly wetted and added to the mortar and the entire mass turned and returned at least six (6) times until all the stone particles are coated with mortar and the mixture is uniform in color. Batches shall not exceed one-half (½) cubic yard in volume.

67.30. **Retempering.** Retempering of concrete or mortar which has reached its initial set or partially hardened, by remixing with or without additional materials, shall not be permitted.

67.31. **Handling.** The concrete shall be placed in the forms immediately after mixing and in such manner as to avoid the separation or segregation of the aggregate. The mixing plant shall be equipped and arranged so as to permit the mixing and placing of the concrete quickly and uniformly. In case concrete is handled by chutes the resulting concrete shall be satisfactory to the Engineer. In depositing concrete all of the following precautions shall be observed.

(a) In handling the concrete from the mixer to the place of deposit, care shall be taken to avoid any separation of the materials.

(b) When concrete is deposited through chutes, the angle of the same with the horizontal shall be such as will allow the concrete to flow slowly and without separation of the aggregate. The delivery from the spout shall be as close as possible to the point of deposit. Dropping the concrete a distance of more than five (5) feet will not be permitted.

(c) Chutes shall preferably be of metal, but if of wood, metal lined. They shall be kept clean and free from material adhering to their sides and shall be thoroughly flushed with water before and after each run.

(d) Depositing large quantities at one point in the forms, and running and working it along the forms, will not be permitted.

(e) In depositing the concrete, care shall be taken to entirely fill the form but not to bulge or distort the forms or to disturb their alignment.

(f) Special care shall be taken in filling the forms, to work the coarser aggregate away from the face of the forms and to force the concrete under and around the reinforcement. The concrete shall be worked with a spade, pointed steel rod, or other satisfactory implement, in such a manner as to bring a thick layer of mortar in contact with the forms and reinforcement, and to prevent the formation of pockets of stone.

(g) Concrete shall be placed in continuous horizontal layers, the thickness of which generally shall not exceed ten (10) to twelve (12) inches. When it is necessary by reason of an emergency to place less than a complete horizontal layer at one operation, such layer shall terminate at a vertical bulkhead. In any given layer the separate batches shall follow each other so closely that each one shall be placed and compacted before the preceding one has taken initial set, in order that the green concrete shall not be injured and that there shall be no line of separation between the batches. Each layer of concrete shall generally be left somewhat rough to secure efficient bonding with the next layer above. A succeeding layer placed before the under layer has become set shall be compacted in a manner that will entirely break up and obliterate the tendency to produce a construction joint between layers.

67.32. **Depositing Under Water.** In general, concreting under water shall be avoided and it will be permitted only when provided for on the plans, or when specifically authorized by the Engineer and under his direct supervision.

The cofferdams shall be sufficiently tight to prevent any current passing through the space in which the concrete is to be deposited. Pumping will not be permitted in the cofferdams while the concrete is being placed nor until it has reached its initial set.

All concrete deposited under water shall conform to the requirements of Class "A" concrete to which shall be added ten (10) per cent of excess cement.

The flow of concrete shall be continuous, or in case the flow is interrupted the cofferdam shall be pumped out, and all laitance removed before proceeding with the work. The concrete shall be deposited as nearly as practicable in horizontal layers.

The method used in depositing the concrete shall be such as will not permit the washing of the cement from the concrete. The following approved methods may be used under the direct supervision of the Engineer.

(a) **Tremie.** If a tremie is used, it shall consist of a tube twelve (12) to sixteen (16) inches in diameter, constructed in sections, with flanged couplings with gaskets and so placed as to permit the initial and all subsequent charging to take place without the concrete being dropped through the water. In operating the tremie it shall be kept filled at all times and the discharge end shall be raised only an amount sufficient to permit the concrete to discharge. Provisions shall be made in supporting the tremie so that it may be readily lowered when necessary to "choke off" or retard the flow.

(b) **Dump bucket.** A dump bucket may be used if so designed that it may be opened when it rests upon the surface of the concrete which is to receive the charge. The bucket shall be filled level full and in lowering and raising the bucket, care shall be taken to prevent any unnecessary movement of the water in the cofferdam.

67.33. **Protection and Curing.** All concrete shall be properly protected from extremes of heat and cold until well seasoned. Surfaces exposed to premature drying shall be kept covered and shall be kept damp for from at least five (5) to ten (10) days according to the weather conditions, and as directed by the Engineer.

67.34. **Cyclopean or Rubble Concrete.** Rubble or cyclopean aggregate may be used in unreinforced sections two (2) or more feet in thickness. The stone shall be set in place by hand (not cast or thrown into the concrete) for one-half (½) the depth of the stone, and shall be not less than four (4) inches apart in the concrete and not less than six (6) inches from the face of any form. No course of stone shall extend within two (2) feet of the top surface of piers or the surface upon which the super-structure rests. The stone shall be thoroughly wetted before placing in concrete.

67.35. **False Work.** False work for supporting concrete work shall be built on foundations of sufficient strength to carry the load without appreciable deformation. False work which cannot be founded on solid footings must be supported by ample false work piling. False work shall be designed to carry the full loads coming upon it.

For single span bridges false work shall be given a permanent camber equal to one-fortieth (1-40) inch per foot of clear span. Multiple span bridges shall be given the amount of camber specified on the plans.

In general, double wedges or other suitable means shall be provided for constructing and maintaining false work and forms to correct lines.

On important structures, when requested by the Engineer, the contractor shall submit plans for false work and forms for checking and approval before the false work is constructed.

67.36. **Forms.** Wood or metal forms shall be constructed of materials sufficient in strength to hold the concrete without bulging between supports. If the forms bulge or sags at any point when the concrete is placed in them, the portion of concrete causing the distortion shall be immediately removed and the forms properly repaired and strengthened before continuing the work.

In designing forms and centering the concrete shall be treated as a liquid weighing one hundred fifty (150) pounds per cubic foot for vertical loads and eighty-five (85) pounds per cubic foot for horizontal pressure. The unsupported length of the wooden columns and comperession members shall not exceed thirty (30) times the diameter or least side.

The material to be used in wood forms for exposed surfaces shall be sized and dressed lumber, free from knot holes, loose knots, cracks, splits, or other defects affecting its strength or the accuracy or the appearance of the finished concrete surfaces. Tongue and grooved material may be required by the Engineer. If metal forms are used all bolt and rivet holes shall be counter-sunk so that a plane smooth surface will be obtained.

Forms shall be so designed and constructed that they may be removed without injury to the concrete. Blocks and bracing shall be removed with the forms and in no case shall any portion of the wood forms be left in the concrete. Special attention shall be paid to the ties and bracing, and where the forms appear to be insufficiently braced, or unsatisfactorily built, either before or during construction, the Engineer shall order the work to be stopped until the defects have been corrected to his satisfaction. The forms shall be so constructed that the finished concrete shall be of the form and dimensions as shown on the plans and true to line and grade.

Forms shall be filleted at all sharp corners and should be given a bevel in the case of all projections such as girders, copings, etc., sufficient to insure their easy removal.

To insure a first-class surface finish on the concrete, the forms shall be painted with a colorless oil, or some other satisfactory means taken to prevent the concrete adhering to them. The forms should be thoroughly drenched with water immediately before the concrete is placed in them. Form lumber which is used a second time shall be thoroughly cleaned and shall be free from bulges, splits or warps.

67.37. **Removal of Forms.** To permit proper surface finish, forms shall in general, be removed as soon after the concrete has set as practicable and safe.

Forms for ornamental work, railing, parapets, and vertical surfaces that do not carry loads, shall remain in place at least fifteen (15) hours after the last concrete is placed, and a greater length of time in cool or unfavorable weather.

Forms under slabs, beams, girders, arches and structures or parts of structures carrying loads, except culverts or slabs of eight (8) foot span or less, shall remain in place a minimum of twenty-one (21) days in warm weather or greater length of time in cool or unfavorable weather at the discretion of the Engineer. The forms for slabs having a span of eight (8) feet or less shall remain in place from ten (10) to fourteen (14) days.

67.38. **Joints.** Unless otherwise provided in the detailed plans, the joints in concrete masonry shall be constructed in the following manner.

(a) **Construction Joints.** Construction joints, except where shown on the plans are to be avoided, but when necessary they shall be made under the direction of the Engineer in such places and in such manner that they will have the least possible effect on the strength of the structure. Construction joints shall be perpendicular to the principal lines of stress and in general at points of minimum shear.

In placing concrete in successive horizontal layers in walls, piers, abutments, etc., construction joints between layers of concrete placed intermittently shall be properly bonded. The surface of each layer shall be left rough and bond provided as shown on the plans or directed by the Engineer. Bond stones shall be placed as prescribed in paragraph 67.34 for "Cyclopean or Rubble Concrete."

When new concrete is to be placed in contact with old concrete or concrete which has already reached its final set, the surface of the concrete shall be roughened and cleaned of all laitance, dirt or other foreign materials and thoroughly wetted. The amount of coarse aggregate in the batches of concrete placed directly against the old concrete, shall be reduced, so as to give an excess of mortar at the contact surfaces.

(b) **Sliding Joints.** Where sliding joints are to be provided at the ends of slabs, girders or beams or between walls, etc., the surface of the supporting concrete shall be given a smooth finish and covered with two layers of three ply roofing felt to separate the concrete.

(c) **Expansion Joints.** Unless otherwise shown on the plans expansion joints shall be filled with an approved asphalt and felt material. The thickness of the joints shall be one-quarter (1/4) inch where the length of the moving concrete is twenty (20) feet or less, one-half (1/2) inch for lengths of twenty-one (21) to thirty-six (36) feet, three-quarters (3/4) of an inch for lengths of thirty-seven (37) to fifty (50) feet.

(d) **Water Tight Joints.** Special water tight and flashed joints shall be constructed as shown on the plans or prescribed in the special provisions.

67.39. **Surface Finish.**

(a) **General.** The external surface of all concrete masonry shall be thoroughly worked, while the concrete is being placed, by using a fork or concrete spade of an approved type. The working shall be such as to force coarse aggregate particles from the surface and work the mortar against the forms and around the reinforcing.

As soon as the forms are removed all wires or fastenings shall be cut and recessed, or pushed back with a centering punch, so that the ends will be at least three-eights (3-8) inch from the finished surface. "Honey comb" or stone pockets shall be cut out as directed by the Engineer, and after the surface has been thoroughly wetted, all holes and depressions shall be carefully pointed with a mortar of sand and cement mixed in the same proportion as was used in the concrete.

Unless otherwise provided on the plans or set forth in the special provisions, railings, posts, curbs, copings, pier caps and pilasters under arches, exposed sides of arch rings, outside of girders, brackets, faces of abutments, and wing walls or other portions of the structure exposed to frequent close view shall be given a rubbed finish.

Panel work and spandrel walls of arches shall be given a rough finish.

The surface of piers, bents, walls and the underside of slabs, girders, arches and bents shall be pointed up without further finish; except when the surface will be exposed to view, excessive form marks and irregularities shall be removed and sufficient finishing done to present a reasonably uniform or pleasing appearance.

(b) **Rubbed Finish.** A rubbed finish shall be obtained by rubbing the surface to be finished, as soon as practicable after it has been pointed up, with a wood float or mortar block and clear water until all form marks or irregularities of the surface are removed. A No. 16 carborundum brick shall be used to remove irregularities which cannot be removed with the wood float or mortar brick. The use of plaster or neat cement wash shall not be allowed.

(c) **Special Finish.** As soon as the pointing has been completed and set so as to permit, the entire surface to be treated shall be thoroughly wet by means of a brush and clear water and immediately thereafter thoroughly rubbed with a No. 16 carborundum stone to bring the surface to a lather. All form marks and projections shall be removed by the use of a carborundum stone. The entire surface shall then be lightly brushed with a coat of sand and cement in the proportion of one (1) part of cement to two (2) parts of sand. The sand used shall pass a twenty (20) mesh sieve. The final finish shall be obtained by rubbing with a No. 30 carborundum stone until the entire surface is of a smooth texture. After the final rubbing, the entire surface shall be drenched with water and kept wet for a period of seven (7) days unless otherwise directed by the Engineer. Handrail spindles or other members which have become disfigured by the drip from the carborundum stone, shall be thoroughly cleaned by means of adilute solution of muriatic acid.

(d) **Rough Finish.** To obtain this finish the forms must be removed within forty-eight hours after concrete is poured. After the surface has been pointed up it shall be thoroughly rubbed with stiff wire brushes and clear water until the surface skin of mortar has been removed, partially exposing the coarse aggregate. The finish shall be used only when called for on the plans.

67.40. **Basis of Payment:** The contract price per cubic yard for the various classes of concrete will be payment in full for all concrete materials, false work, forms, equipment, labor, finishing and other materials and incidental expenses entering into concrete construction, which shall include placing weep holes, pipes, conduits, anchor bolts, etc. Reinforcing steel, expansion plates or other metal shall be paid for separately unless otherwise provided on the plans.

The cost of excavation shall not be included in the price of concrete unless specifically so stated on the plans or in the proposal.

If a bid is asked for on railing, that portion of the structure above the top of the curbs shall not be included in the yardage of concrete, but shall be paid for as railing. The contract price per linear foot for railing shall include the cost of all materials, reinforcing steel, labor, finishing, forms and other items necessary to complete the railing as shown.

Payment will be made under
- Item No. 66, Class "A" Concrete (cubic yard).
- Item No. 67, Class "B" Concrete (cubic yard).
- Item No. 68, Class "C" Concrete (cubic yard).
- Item No. 69, Class "D" Concrete (cubic yard).
- Item No. 70, Concrete Hand Rail (per linear foot).

SECTION 68

REINFORCEMENT IN STRUCTURES

68.01. **Description:** Under this item reinforcing steel, consisting of deformed bars shall be furnished and placed as called for on the plans or as directed. When deformed bars are specified, the form of the bar used must be approved by the Engineer and shall be such as to provide a net section at all points equivalent to that of a plain square or round bar of equal nominal size. Cold twisted bars shall be used only with the permission of the Engineer.

MATERIALS

68.02. (a) **Bar reinforcement:** Reinforcement metal for concrete structures shall be manufactured in accordance with and shall in all respects fulfill the physical and chemical requirements of the American Society for Testing Materials, Standard Specifications for Billet Steel Reinforcement Bars serial designation A-15-14 with any subsequent amendments and additions thereto adopted by the Society.

Unless otherwise designated upon the plans, all bar reinforcement shall be of open hearth steel of the structural or intermediate grade.

When deformed bars are specified, the form of the bar used must be such as to provide a net section at all points equivalent to bars that of a plain square or round bar of equal nominal size. Twisted bars will be used only by permission of the engineer.

For small single culverts, spans not exceeding five (5′) feet, reinforcement material may be of rail steel reinforcement bars, meeting the requirements of the specifications of the American Society for Testing Materials, serial designation A-16-14.

68.03. (b) **Mesh Reinforcement:** Reinforcing materials shall consist of a steel fabric manufactured from steel meeting the requirements of the American Society for Testing Materials, serial designation A-82-21-T.

Reinforcement shall be free from excess rust, scale or coating of any character which will impair its bond with the concrete. Fabric reinforcement shall consist of members rigidly attached at all joints, or points of intersection and shall have an effective weight of approximately forty-four (44) pounds per one hundred (100) square feet. The spacing of the main members of the fabric shall not be more than six (6) inches nor less than four (4) inches. Tie members to be spaced not more than twelve (12) inches nor less than eight (8) inches. The effective cross sectional area of the main members shall not be less than 0.10 sq. in. per foot of fabric. The effective cross sectional area of the tie members shall not be less than twenty-five hundred (.025) sq. in. per foot of the fabric. Unless otherwise noted on plans reinforcing conforming to the above specifications will be the standard.

CONSTRUCTION METHODS

68.04. **Handling and Placing:** Metal reinforcement, before being placed, shall be thoroughly cleaned of mill and rust scale and of coatings of any character that will destroy or reduce the bond. Reinforcement appreciably reduced in section shall be rejected. In case reinforcement which has been placed, becomes spattered with mortar which dries out before concrete is placed around it, such reinforcement shall be thoroughly cleaned before being covered with concrete.

The reinforcement shall be bent to the required shapes. The radius of bend shall be four (4) or more times the least diameter of the bar.

The reinforcement shall be accurately placed, and secured against displacement before any concrete is placed, by using annealed iron wire of not less than No. 18 gauge, or suitable clips at intersections, and shall be supported by concrete blocks.

68.05. **Spacing Reinforcement:** Where the spacing of reinforcement is not definitely shown on the plans, the following general rule shall govern:

Beams and Girders. The distance between the centers of bars shall be not less than D plus A plus ½ inch, not less than 3D, where A equals maximum screen openings specified for coarse aggregate, D equals nominal diameter of bar.

Distance from side form to center of nearest bar shall not be less than D plus A plus ¼ inch, nor a clear distance of less than 1 inch.

Distance from bottom form to centers of bars in bottom layer shall not be less than ½D plus A plus ¾ inch, nor less than 2D.

Slabs: The distance from bottom and top surface of concrete to center of bars shall not be less than ½D plus 1 inch.

68.06. **Splicing:** Splices of tension reinforcement at points of maximum stress shall be avoided. Bars to be spliced shall be securely wired together and unless otherwise shown on the plans shall have a lap of not less than fifty times the nominal diameter of the bar for plain bars or forty times the nominal diameter for deformed bars.

68.07. **Method of Measurement:** The weight of steel to be paid for shall be the theoretical weight of the steel placed as shown on the plans and accepted. The unit weight used for deformed bars shall be the weight of plain square or round bars, as the case may be, of equal nominal size.

The weight of the steel actually placed shall not vary more than two per cent from the calculated weights.

68.08. **Basis of Payment:** This item will be paid for at the contract unit price per pound for "Reinforcing Steel" described on plans, which price shall be full compensation for furnishing the material, equipment, tools, labor and incidentals necessary to complete the item. No allowance will be made for the clips, wire, separators, or other material used for fastening the reinforcing in place.

When there is no separate item for structural steel metal drains or expansion plates used in the construction of concrete bridges, these will be paid for at the same price bid for steel reinforcement unless otherwise provided.

Payment will be made under
Item No. 71 (a)—Bar Reinforcing Steel (per pound).
Item No. 71 (b)—Steel Mesh Reinforcing (per pound).

SECTION 69

STEEL STRUCTURES

69.01. **Description:** In these Specifications, "Steel Structures" embraces all construction composed of structural steel, together with the appurtenant metal details regardless of the composition of the latter.

Unless otherwise directed, these structures shall be constructed to the design, dimensions, lines, and grades, indicated on the plans, and in accordance with the methods and with the materials of the quality fully described in these Specifications.

MATERIALS

STRUCTURAL RIVET AND EYEBAR STEEL

69.02. **General:** All Structural, rivet and eyebar steel shall conform to the requirements of the Standard Specifications for structural steel for Bridges. Serial Designation A7-24, of the American Society for Testing Materials, with subsequent amendments and additions there-to adopted by the Society, and supplemented by the following paragraphs:

69.03. **Character of Fracture:** Test specimens of structural, rivet or eyebar steel shall show a fracture having a silky or fine granular structure throughout with a bluish gray or dove color, and shall be entirely free from granular, black and brilliant specks.

69.04. **Defects in Material:** Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges, and other defects. It shall have a smooth, uniform finish and shall be straightened in the mill before shipment.

Material shall be free from loose mill scale, rust pits, or other defects affecting its strength and durability.

69.05. **Full Size Tests:** When full-size tests of built up structural members and eyebars are required by the contract the Contractors shall supply testing machines of the proper type and capacity and shall provide all facilities and labor incidental to the making of tests. In all tests involving the determination of tensile and compressive strengths the ultimate strength. Deformation and other pertinent data shall be recorded.

69.06. **Payment for Full-Size Tests:** Any full-size member tested to destruction shall be paid for by the Purchaser at the unit contract price, less its scrap value, if the test proves satisfactory. If the test proves the member to be unsatisfactory, the members represented by it will be rejected. The expense of conducting tests shall be borne by the Contractor unless otherwise provided.

EYEBARS

69.07. **Full Size Tests:** When tests of full-size bars are required the following conditions and requirements shall supplement the general provision of Paragraph 3.15.04.

69.08. **Number and size of Test Bars:** The number and size of the bars tested shall be designated by the Engineer before the mill order is placed. The number shall not exceed five (5) per cent of the whole number of bars ordered, with a minimum of two (2) bars on small orders.

69.09. **Selection of Test Bars:** The test bars shall be of the same section as the bars to be used in the structure and of the same length if within the capacity of the testing machine. They shall be selected by the Inspector from the finished bars, preferably after annealing. Test bars representing bars too long for the testing machine shall be selected from the full-length bar material after the heads on one end have been formed and shall have the second head formed upon them after being cut to the greatest length which can be tested.

69.10. **Physical Requirements:** Full-size tests of eyebars shall show a yield point of not less than twenty-nine thousand (29,000) pounds per square inch, an ultimate strength of not less than fifty-four thousand (54,000) pounds per square inch, and an elongation, including fracture, of not less than ten (10) per cent in a length of twenty (20) feet measured in the body of the bar. The fracture shall show a uniform silky or fine granular structure throughout.

69.11. **Failure to Meet Requirements:** If a bar fails to fulfill the specified requirements, two additional bars of the same size and from the same melt shall be tested. If the failure of the first bar tested is on account of the character of the fracture only, the bars represented by the test may be re-annealed before the additional bars are tested. If two of the three test bars fail to give satisfactory results, the bars of that size and mill heat shall be rejected. A failure in the head of the bar shall not be cause for rejection if the other requirements are fulfilled. The bars shall be so selected that every melt of material entering into the various sizes of bars shall be represented by at least one test.

69.12. **Record of Annealing:** A failure in the head of a bar shall not be cause for rejection if the other requirements are fulfilled. A record of the annealing charges shall be furnished the Engineer showing the bars included in each charge and the treatment they received.

STEEL FORGINGS

69.13. **General:** Steel forgings from which pins, rollers, trunions, or other forged parts are to be fabricated, shall conform to the requirements of the Standard Specifications for Carbon-Steel Forgings for locomotives, Serial Designation A20-21, of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the Society.

69.14. **Annealing:** All forgings shall be thoroughly annealed prior to being machined to form finished parts.

WROUGHT-IRON

69.15. Wrought-Iron shall conform to the requirements of the Standard Specifications for Refined Wrought-Iron Bars, Serial Designation A41-18, of the American Society for Testing Materials with subsequent amendments and additions thereto adopted by the Society.

STEEL CASTINGS

69.16. **General:** Steel castings shall conform to the requirements of the Standard Specifications for Steel Castings, Serial Designation A27-24, of the American Society for Testing Materials with subsequent amendments and additions thereto adopted by the Society, and supplemented by the following:

Unless otherwise specified all castings shall be Class B, Medium Grade.

69.17. **Annealing:** All steel castings shall be thoroughly annealed unless otherwise provided.

69.18. **Structural Defects:** Steel castings shall be true to pattern in form and dimensions, free from pouring falts, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended. Blow holes appearing upon finished castings shall be so located that a straight line laid in any direction will not cut a total length of cavity greater than one (1) inch in any one (1) foot, nor shall any single blow hole exceed one inch in any dimension or have an area gerater than one-half (½) squafe inch. Blow holes shall not have a depth injuriously affecting the strength of the casting. Minor defects which do not impair the strength may, with the approval of the Engineer, be welded by an approved process. The defects shall be removed to solid metal by chipping, drilling or other satisfactory methods and, after welding, the castings shall be annealed, if required by the Engineer. Castings which have been welded without the Engineer's permission shall be rejected. Large castings, if required by the Engineer, shall be suspended and hammered all over. No cracks, flaws or other defects shall appear after such treatment. No sharp unfilleted angles or corners will be allowed.

GRAY-IRON CASTINGS

69.19. **General:** Iron castings shall conform to the requirements of the Standard Specifications for Gray-Iron Castings, Serial Designation A48-18, of the American Society for Testing Materials with subsequent amendments and additions thereto adopted by the Society. Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect.

69.20. **Structural Defects:** Iron castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended.

MALLEABLE CASTINGS

69.21. **General:** Malleable castings shall conform to the requirements of the Standard Specifications for Malleable Castings, Serial Designation A47-24, of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the Society. The castings shall be boldy filleted at angles and the arrises shall be sharp and perfect. The surfaces shall have a workmanlike finish.

69.22. **Structural Defects:** Malleable castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended.

PHOSPHOR-BRONZE

69.23. **General:** Phosphor-bronze shall conform to the requirements of the Standard Specifications for Bronze-Bearing Metals for Turn-tables and Moveable Railroad Bridges, Serial Designation B22-21-7-B of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the Society. Grade B metal shall be used.

69.24. **Structural Defects:** Bronze castings shall be free from inclusions of foreign material, casting faults, injurious blow holes and other defects rendering them unsuitable for the service intended.

PAINT

69.25. **General:** Paint for structural steel work shall consist of an approved pigment mixed with an approved vehicle in accordance with the requirements hereinafter set forth.

1. Unless otherwise provided the materials entering into the composition of paints shall conform to the specifications of the Federal Specifications Board issued by the Bureau of Standards and in the examination of paints the methods specified herein shall be used.

2. All pigments, oils, thinners, driers, etc., shall be of the highest quality, free from adulterations, and in compliance with the requirements herein set forth. The various mixtures of pigment and vehicle shall be in the proportions herein enumerated for the particular paint specified.

3. All paints shall be shipped in strong, substantial containers plainly marked, with the weight, color, and volume, in gallons of the paint content and with the name and address of the manufacturer, together with a statement of the percentage composition of pigment and the proportions of pigment to vehicle. Any package or container not so marked will not be accepted for use under these specifications.

4. Where dry pigments are to be used, the dry pigment shall first be thoroughly and uniformly mixed by grinding with oil in a suitable grinding machine to reduce it to a paste consistency, after which additional oil, thinners and driers shall be added to produce the working consistency specified herein below. The oil shall be added a little at a time and well stirred in. In no case shall dry powdered pigments bemixed directly with the total vehicle. Where lamp black or other tinting pigments are used, they shall be used in paste form only. In no case shall dry lamp black or other powdered tinting pigments, be mixed directly with oil.

69.26. **Paint Paste:** Where paint pigments are purchased in paste form, the paste shall consist of the specified pigment or pigments ground to the required consistency in linseed oil. The paste so prepared shall be uniform in consistency and composition and shall not cake or segregate in the containers. When additional vehicle is added, the paint paste shall be such as to readily break up, to form a smooth uniform liquid of the proper brushing consistency and which will not run or sag.

VEHICLE.

69.27. **Definition:** The term vehicle shall be used to designate the mixture of linseed oil with the necessary amount of drier or thinner to preduce an acceptable drying coefficient and a workable consistency. The total amount of volatile vehicle shall in no case exceed ten (10%) of the total vehicle, nor shall the vehicle contain in excess of one (1) per cent of water.

69.28. **Raw Linseed Oil.** The linseed oil shall conform to the requirements adopted by the Federal Specifications Board issued by the Bureau of Standards in Circular No. 82.

The requirements for Raw Linseed Oil are as follows:

	Maximum	Minimum
Loss on heating at 105 to 110°C. (per cent)	0.2	....
Foots by volume (per cent)	2.0	....
Specific gravity 15.5°C.	.936	0.932
Acid number	6.0	....
Saponification number	195.0	189.0
Unsaponifiable matter (per cent)	1.5	....
Iodine number (hanus) a		170.0
Color	Not darker than a freshly prepared solution of 10G potassium bichromate in 100 cc pure strong (1.84 sq. gr.) sulphuric acid.	

69.29. **Boiled Linseed Oil:** Boiled Oil shall be well settled linseed oil that has been boiled with oxides of manganese and lead. It shall conform to the requirements adopted by the Federal Specifications Board in Circular No. 82, which are as follows:

	Maximum	Minimum
Loss on heating at 105 to 110°C. (per cent)	0.2	....
Specific gravity at 15.5°/15/5°C.	0.945	0.937
Acid number	8.0	....
Saponification number	195.0	189.0
Unsaponifiable matter (per cent)	1.50	....
Iodine number (Hanus)		168.0
Ash (per cent)	.7	.2
Manganese (per cent)		.03
Lead (per cent)		.1
Time of drying on glass (hours)	20.0	....

69.30. **Vehicle for Aluminum Paint:** The vehicle for aluminum paint shall be either an exterior varnish or a bodied oil meeting the following requirements:

(a) **Exterior Varnish Material:** The vehicle for use with aluminum bronze powder may either be a specially prepared spar mixing varnish or a bodied linseed oil. The spar mixing varnish for exterior use should fulfill the following requirements:

The varnish shall contain not less than fifty (50) per cent by weight of non-volatile oils and gums, and the ratio of oil to gum shall be not less than three (3) to one (1).

The varnish shall pass a sixty (60) per cent Kauri reduction test, as specified in Federal Board Standard Specification No. 18.

The varnish shall set to touch in not less than two (2) nor more than six (6) hours, and dry hard and tough in not more than twenty-four (24) hours.

The varnish shall be of such consistency that when thoroughly mixed with aluminum bronze powder in the proportion of two (2) pounds per gallon of vehicle, the paint shall show satisfactory spreading qualities, and shall not run or sag when applied to a vertical surface.

(b) **Bodied Oil Vehicle:** The bodied linseed oil vehicle shall be a linseed oil bodied by heat alone, known to the trade as a "kettle bodied" linseed oil or lithographic oil.

The paint shall be of such consistency that when diluted with a volatile thinner in the ratio of six (6) parts linseed oil to four (4) parts thinner and then mixed with two (2) pounds of aluminum bronze powder per gallon of vehicle, the paint shall show satisfactory spreading qualities and shall not run or sag when applied to a vertical surface.

It shall set to touch in not more than ten (10) hours and dry hard in not more than thirty (30) hours.

69.31. **Mixing Aluminum Paint:** Aluminum paint shall be mixed on the job and only enough for one day's use shall be mixed at one time. The paint shall be mixed in the proportion of two (2) pounds of aluminum bronze powder per gallon of vehicle. This makes a paint containing twenty-one (21) per cent pigment and seventy-nine (79) per cent vehicle. The weighed amount of powder shall be placed in a suitable mixing container and the measured volume of vehicle then poured over it. The powder shall be incorporated in the paint by vigorous stirring with a paddle. The powder will readily disperse in the vehicle. Before removing any paint from the mixing container, the paint shall be thoroughly stirred to insure a uniform mixture and the paint shall be suitably stirred during use.

THINNER

69.32. **Turpentine:** The turpentine used shall either be distillate commonly known as "Gum Turpentine" or "Spirits Turpentine" which is distilled from pine oleoresins or the product secured from resinous wood by extraction with volatile solvents, by steam or by destructive distillation, and shall meet the following requirements as given in Circular No. 86 of the Bureau of Standards.

The turpentine shall be clear and free from suspended matter and water.
The color shall be "Standard" or better.
The specific gravity shall be not less than 0.862 nor more than 0.875 at 13.5°C.
The refractive index at 20°C. shall be not less than 1.465 nor more than 1.478.
The initial boiling point shall not be less than 150° nor more than 160°C. at 760 mm. pressure.
Ninety (90) per cent of the turpentine shall distill below 170°C. at 760 mm. pressure.
The polymerization residue shall not exceed two (2) per cent and its refractive index at 20°C. shall not be less than 1.500.

69.33. **Mineral Spirits:** Mineral Spirits shall meet the following requirements as given in Circular No. 98 Bureau of Standards:

Appearance—Shall be clear and free from suspended matter and water.
Color—Shall be "water white."
Spot Test—Shall evaporate completely from filter paper.
Flash Point—Shall be not lower than 30°C. (86°F.) when tested in a closed cup tester.
Sulphur—Shall be absent, as determined by the white-lead test.
Distillate below 130°C. (266°F.) shall not exceed 5 per cent.
Distillate below 230°C. (446°F.) shall not be less than 97%.
Reaction—Shall be neutral.

DRIER

69.34. The drier shall meet the following requirements as given in Circular No. 105 of the Bureau of Standards.

The drier shall be composed of lead, manganese, or cobalt, or a mixture of any of these elements combined with a suitable fatty oil, with or without rosins or "gums" and mineral spirits or a mixture of these solvents. It shall be free from sediment and suspended matter. The drier when flowed on metal and baked for two (2) hours at 100°C. (212°F.) shall leave an elastic film. The flash point shall be not lower than 39°C. (85°F.) when tested in a closed-cup tester. It shall mix with pure raw linseed oil in the proportion of one (1) volume of drier to nineteen (19) volumes of oil without curdling, and the resulting mixture when flowed on glass shall dry in not more than eighteen (18) hours. When mixed with pure raw linseed oil in the proportion of 1 volume of drier to eight (8) of oil, the resulting mixture shall be no darker than a solution 6g, of potassium dichromate in 100cc. of pure sulphuric acid of specific gravity 1.84.

PAINT PIGMENTS

69.35. **Red Lead:** The pigment shall conform to the requirements of the Federal Specifications Board or the A. S. T. M. Standard Specifications for red lead (Serial Designation Ds3-24 with subsequent amendments and additions thereto) for the ninety-five (95) per cent grade.

69.36. **Graphite:** The pigment in both semipaste and ready mixed paint shall consist of finely ground graphitic carbon and insoluble siliceous material. The graphitic carbon may be derived from either natural or artificial graphite and the insoluble siliceous matter may be either the naturally occuring insoluble impurities of the graphite or added insoluble siliceous matter. The pigment shall show on analysis not less than fifty (50) per cent praphitic carbon and not less than thirty (30) per cent insoluble siliceous matter. The sum of the graphitic carbon and insoluble siliceous matter shall be not less than eighty-five (85) per cent. Nor more than five (5) per cent of calcium and magnesium carbonate and sulphates shall be present.

The pigment shall be ground so that it will all pass through a 200-mesh sieve.

59.37. **Carbon Black:**

(a) Carbon black shall be either gas carbon or lamp black. Its color and tinting strength shall be equal to a "standard" sample submitted and approved.

(b) Gas carbon shall be obtained by burning natural gas. It shall not contain more than a minute trace of grease or other benzine soluble impurities, nor more than 0.5% of ash.

(c) Lamp black shall be obtained by burning oils. It shall contain no more than a minute trace of grease or other benzine soluble impurities, nor more than 0.5% of ash.

69.38. **Basic Carbonate White Lead:** This pigment shall conform to the requirements of the Federal Specifications Board or the A. S. T. M. standard specifications for basic carbonate white lead (Serial Designation D81-24 with subsequent amendments and additions thereto.)

69.39. **Basic Sulphate White Lead:** This pigment shall conform to the requirements of the Federal Specifications Board or A. S. T. M. standard specifications for Basic Sulphate White Lead. (Serial Designation D82-24 with subsequent amendments and additions thereto.)

69.40. **Pure Zinc Oxide:** This pigment shall conform to the requirements of the Federal Specifications Board of the A. S. T. M. standard specifications for zinc oxide. (Serial Designation D79-24 with subsequent amendments and additions thereto.)

69.41. **Leaded Zinc Oxide:** This pigment shall conform to the requirements of the Federal Specifications Board or the A. S. T. M. standard specifications for leaded zin coxide. (Serial Designation D80-24 with subsequent amendments and additions thereto.)

69.42. **Yellow Ochre:** All yellow ochre shall be pure French Ochre, and shall not contain less than nineteen (19) per cent of Iron Oxide nor more than five (5) per cent of Lime in any form.

69.43. **Asbestine:** Asbestine (Magnesium silicate) shall be finely ground, free from grit, adulterants or impurities other than silicate of iron, alumina, lime and manganese. It shall show under a microscope the characteristic crystalline structure of asbestine.

69.44. **Red Oxide of Iron:** Red Oxide of Iron shall contain not less than sixty-five (65) per cent of oxide of iron (Fe2O3) the remainder being silica and silicates. It may contain sulphur as calcium sulphate not to exceed 0.10%.

69.45. **Tinting Pigments:** Lamp Black, lead chromate, Prussian Blue, or Ochre may be employed as tinting pigments. Other pigments may be submitted to the Engineer and if approved may be used under these specifications, subject to such limitations as the Engineer may prescribe. All tinting pigments shall be added in paste form.

Lamp black paste shall be lamp black mixed with linseed oil in the following proportions:

Dry lamp black	20%
Linseed oil	80%
Weight of one gallon of paste	9¼ lbs.

Lead Chromate and Prussian Blue (or a mixture of the two—Chrome Green) shall be of the highest commercial quality, free from adulterants or any impurities in excess of two (2) per cent. The total amount of water soluble material shall not exceed one-half (½) of one per cent.

Ochre Paste shall conform to the requirements of the Federal Specifications Board or the A. S. T. M. standard specifications for Ochre (Serial Designation D85-24 with subsequent additions and amendments thereto.)

Inert pigments, where used, shall be silica, magnesium silicate, aluminum silicate, barium sulphate, pure tinting colors or any mixture thereof. Inerts shall in no case contain organic coloring matter, soap or emulsifying products.

No pigment containing coal tar or asphaltic products shall be used.

69.46. **Aluminum, Powdered:** Powdered Aluminum shall be made by the best commercial methods from metallic aluminum having a minimum aluminum content of ninety-nine (99) per cent (To determine from the finished powder that this requirement has been met, a sample shall be analyzed for iron, silicon, and copper. The toal weight of these impurities shall not exceed one (1) per cent of the weight of the sample after deduction of the acetone soluble portion.)

(a) The powder shall conform to the following composition limits:

Acetone extract (2 hrs.) maximum	3.0%
Lead and zinc maximum	0.0%
Copper maximum	0.2%

(b) Powdered Aluminum shall be powdered in the forms of flakes and shall be polished. It shall possess the property of "leafing," when suspended in varnish or airplane dope.

(c) The fineness shall be such that it will pass through a standard 100 mesh screen.

(d) Powdered Aluminum shall contain no adulterants such as powdered mica.

PAINT FORMULAS

69.47. **Shop Coat:** For the first or priming coat or for any maintenance coat placed on bare metal the following paint shall be used:

Red lead paste (95% grade)	33-1/3 lbs.
Linseed oil	1.0 gals.
Total volume of paint produced by above quantities approximately	1.75 gals.
Weight of resulting paint per gallon (before addition of any thinner or drier) approximately	24.0 lbs.

To each gallon of the paint prepared as above, may be added such amounts of thinner or drier as are necessary to secure work-ability and a good drying coefficient, but in no case shall the amounts so added be such as to cause a separation of pigment and vehicle, nor shall they exceed the following:

Maximum amount of drier per gallon of paint, 1/3 pint.

Maximum amount of thinner per gallon of paint, 1/3 pint.

For ordinary bridge work, the linseed oil used shall consist of a mixture of raw and boiled oils in the proportion of from 1/3 to ½ boiled oil, the balance being raw oil.

For work exposed to water action, boiled linseed oil shall be used and the amount of drier used shall be not more than 50% of the value specified above.

The above formula percentages are in terms of the paste pigment which contains about seven (7) per cent of oil. Reduced to equivalent dry pigment percentages, the formula is as follows:

Red Lead (95% grade)	24.0 lbs.
Linseed Oil	1.0 gal.
Total gallons of paint produced from above quantities approximately	1.33 gals.

69.48. **First Field Coat:** First Field Coat after all abrasions of the shop coat have been repaired shall be the same as the shop coat with approved Carbon Black added as may be needed for tinting.

Red Lead Paste (95% grade)	33-1/3 lbs.
Approved Carbon Black Paste (as noted for tinting) from	1/8 to 1/4 lbs.
Linseed Oil	1.0 gal.
Weight per gallon of paint (without drier or thinner) approximately	24.0 lbs.

Raw Linseed Oil or a mixture of raw and boiled oils containing not to exceed twenty-five (25) per cent of boiled oil, shall be used as a vehicle, except for work exposed to water action, in which case boiled oil shall be used as noted herein above under shop coat.

69.49. **Second Field Coat:**

(a) **Black Graphite Paint:**

Graphite Pigment	5.25 lbs.
Linseed Oil Vehicle	1.0 gals.
Total volume of paint produced approximately	1.24 gals.
Weight of paint per gallon before addition of any thinner or drier approximately	10.5 lbs.

A paint conforming to the following requirements with or without tinting may be used for the second field coat.

This paint may be tinted to an olive green or dark green by adding Chrome Yellow or Chrome Green until the desired shade of color is obtained.

(b) **Alternate Second Field Coat:**

Carbon Black	¾ lb.
Lead Carbonate	¾ lb.
Linseed Oil	1.0 gal.
Total volume of paint produced approximately	1.06 gals.
Weight of paint per gallon before addition of any thinner or drier approximately	8.7 lbs.

(c) **Alternate White and Grey Coats:**

This paint may be used for either first or second field coat or both if tinted so that the coats applied can be distinguished.

(1) **White Lead Carbonate:**

Basic Lead Carbonate Paste	19.0 lbs.
Linseed Oil	1.0 gal.
Total volume of paint produced approximately	1.534 gals.
Weight of paint per gallon before addition of any thinner or drier approximately	17.44 lbs.

Note: Basic Sulphate White Lead may be used in place of the Carbonate if approved by the Engineer.

(d) **Alternate White Lead Paint:**

(2) **White Lead and Zinc Oxide:**

Basic Lead Carbonate Paste	12.0 lbs.
Zinc Oxide Paste	8¾ lbs.
Linseed Oil	1.0 gal.
Total volume of paint produced approximately	1.65 gals.
Weight of paint per gallon before addition of any thinner or drier approximately	17.78 lbs.

Note: The above white paints may be tinted to produce a grey by the addition of lamp black paste or carbon black, if desired by the Engineer.

69.50. **Maintenance Paint:**

Red Lead Paste (95% grade)	17.0 lbs.
Graphite	2.0 lbs.
Zinc Oxide	1.0 lbs.
Linseed Oil	1.0 gal.
Total volume of paint produced by the above quantities approximately	1.49 gals.
Weight of resulting paint per gallon (before addition of any thinner or drier) approximately	1.86 lbs.

To the above formulas may be added such amount of thinner and drier as is necessary to secure workability and a suitable drying coefficient but in no case to exceed the requirements specified for shop coat.

The formulas above are based on using the pigments in the paste which is assumed to be made up as follows:

PASTE PROPORTIONS—WEIGHTS AND VOLUME

	Weight Pounds	Pigment Pounds	Linseed Oil Pounds	Volume Gallon
Red Lead, 95% grade	100	93	7	2.16
White Lead Carbonate	100	92	8	2.75
White Lead Sulphate	100	90	10	2.80
Zinc Oxide	100	84	16	3.75
Graphite	100	....	....	....
Carbon Black (drop)	100	50	50	....
Lamp Black	100	20	80	....
Chrome Green	100	70	30	....
Chrome Yellow	100	70	30	....
Ochre	100	70	30	....

Note: One gallon of linseed oil weighs 7.76 pounds.

TESTS AND ACCEPTANCE

69.51. **Manufacturer's Guarantee:** The manufacturer of each brand of paint submitted for acceptance under these specifications, or any contractor desiring to use any particular paint for work to be done under these specifications, shall file with the State a certificate of analysis and manufacturer's guarantee, setting forth the trade name or brand of the paint to be furnished together with a facsimile copy of the label (if the material is of the ready mixed type) and a typical analysis showing the percentage of each of the chemical elements in the pigment and vehicle. The manufacturer's guarantee shall provide that all paint furnished under these specifications shall conform to the certified analysis as filed and to the statement of the various percentage of the ingredients on the receptacle or container. The manufacturer's guarantee shall be of the form furnished by the engineer and shall be sworn to by a person having legal authority to bind the manufacturing company by his acts.

69.52. **Sampling and Testing:** At least thirty (30) days before shop painting starts, the Contractor shall submit for examination and test samples of the particular brand of paint which he proposes to use.

Field paint shall also be submitted for examination in sufficient time to allow at least thirty (30) days for test. No paint shall be used until it has been accepted for use, in writing by the engineer.

In sampling paint for test, the engineer shall take at least one (1) quart sample from every five (5) barrels in the consignment. These samples may be tested individually or as a composite representing not more than twenty-five (25) barrels.

From time to time during the progress of the work, samples of paint used on the work will be taken and subjected to laboratory tests, as may be deemed advisable. A material difference in composition or working quality of these samples, as compared with samples originally furnished by the contractor, or as compared with the manufacturer's guarantee analysis may be considered sufficient reason for cancellation of the contract or for the suspension of any further payment for work done with the defective materials.

69.53. **Inspection:** The Contractor or manufacturer, shall allow the engineer, or his inspector, free access to all parts of his shops while work on these paints is being carried out; and shall give him every reasonable facility to enable him to insure that the paints are being made in accordance with this specification.

CONSTRUCTION METHODS

69.54. **Storage of Materials:** Structural material delivered at the bridge shop receiving yard shall be stored above the surface of the ground upon platforms, skids or other supports and shall be protected as far as practicably from surface deterioration by exposure to conditions producing rust. It shall be kept free from accumulations of dirt, oil or other foreign matter.

Fabricated material stored prior to shipment shall be subject to the same conditions of storage as the unfabricated material in the shop receiving yard.

69.55. **Straightening Material:** All deformed structural material shall be properly straightened by methods which are non-injurious prior to being laid off, punched or otherwise worked in the shop. Sharp kinks and bends shall be cause for rejection.

69.56. **Workmanship and Finish:** The workmanship and finish shall be first class and equal to the best practice in modern bridge shops. Shearing and chipping shall be neatly and accurately done and all portions of the work exposed to view shall be neatly finished.

69.57. **Changes and Substitutions:** No changes shall be made in any drawing after it has been approved except by the consent or direction of the Engineer in writing.

Substitutions of sections having different dimensions than those shown on the plans shall be made only when approved in writing by the Engineer.

69.58. **Rivet Holes:** When general reaming is not required, holes in material three-quarters (¾) inch or less in thickness may be punched full-size. Holes in material more than three-quarters (¾) inch in thickness shall be sub-punched and reamed, or drilled from the solid.

69.59. **Punched Holes:** Full-size punched holes shall be one-sixteenth (1-16) inch larger than the nominal diameter of the rivet. The diameter of the die shall not exceed the diameter of the punch by more than three thirty-seconds (3-32) inch. Holes must be clean cut, without torn or ragged edges. If any holes must be enlarged to admit the rivets, they shall be reamed.

69.60. **Accuracy of Punched Holes:** The punching of holes shall be so accurately done that, after assembling the component parts of a member, a cylindrical pin one-eighth (1-8) inch smaller than the nominal diameter of the punched hole may be passed through at least seventy-five (75) of any group of one hundred (100) contiguous holes in the same surface or in like proportion for any group of holes. If this requirement is not fulfilled the badly punched pieces shall be rejected. If any holes will not pass a pin three-sixteenth (3-16) inch smaller than the nominal diameter of the punched hole, this shall be cause for rejection.

69.61. **Drilled Holes:** Drilled holes shall be one-sixteenth (1-16) inch larger than the nominal diameter of the rivet. Burrs on the outside surfaces shall be removed with a tool producing a one-sixteenth (1-16) inch fillet around the edge of the hole.

69.62. **Sub-Punched and Reamed Holes:** Sub-punched and reamed holes for rivets having diameters greater than three-quarters (¾) inch shall be punched three-sixteenth (3-16) inch smaller than the nominal diameter of the rivet, and for rivets having diameters three-quarters (¾) inch or less the holes shall be punched one-sixteenth (1/16) inch less than the nominal diameter of the rivet. The punch and die shall have the same relative sizes as specified for full-size punched holes. After punching, the holes shall be reamed to a diameter one-sixteenth (1/16) inch larger than the nominal diameter of the rivet. Burrs resulting from reaming shall be removed with a tool producing a one-sixteenth (1/16) inch fillet around the edge of the hole.

Reaming of rivet holes shall be done with twist drills or with short taper reamers. Reamers preferably shall not be directed by hand. No oil or grease shall be used as a lubricant.

69.63. **Accuracy of Reamed and Drilled Holes:** Reamed or drilled holes shall be cylindrical and perpendicular to the member and their accuracy shall be the same as specified for punched holes except that, after reaming or drilling, eighty-five (85) of any group of one hundred (100) contiguous holes in the same surface, or in like proportion for any group of holes, shall not show an offset greater than one-thirty-second (1/32) inch between adjacent thicknesses of metal.

69.64. **Drifting of Holes:** The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal.

69.65. **General Reaming:** General reaming may be required, in which case a definite provision to this effect shall be included elsewhere in the contract.

When general reaming is required, all rivet holes in main members shall be sub-punched and reamed or drilled from the solid. This requirement shall not apply to rivet holes in top and bottom chord lateral members, lateral hangers, truss and girder sway bracings, and to the lateral plates, connection angles, etc., connecting these members to the main members of the structure. Connection plates or other parts acting both as main member material and secondary (lateral, sway bracing, etc.) member material shall generally have sub-punched and reamed holes in locations engaging similar holes in main members.

Reaming shall be done after the pieces forming a built member are assembled and firmly bolted together. No interchange of reamed parts will be permitted.

69.66. **Reaming of Field Connections:** When general reaming is required, or in punched work when specifically required by the Engineer, holes for field connections, except those in lateral, longitudinal and sway bracing, shall be reamed or drilled. Riveted trusses shall be assembled in the shop, the parts adjusted to line and fit, and the holes for field connections reamed or drilled while so assembled. Holes for other field connections shall be reamed or drilled with the connecting parts assembled, or else reamed or drilled to a metal templet not less than one (1) inch thick.

69.67. **Shop Assembling:** All surfaces of metal to be in contact when assembled shall be carefully painted with one coat of the paint specified for the shop coat. The paint shall be applied upon surfaces free from dirt, loose mill scale or other foreign matter and the parts shall be assembled while the paint is plastic.

The component parts of a built member shall be assembled, drift-pinned to prevent lateral movement, and firmly bolted to draw the parts into close contact before reaming, drilling or riveting is begun. Assembled parts shall be taken apart, if necessary, for the removal of burrs and shavings produced by the remaining operation.

The member shall be free from twists, bends or other deformations.

Preparatory to shop riveting full-size punched material, the rivet holes shall be cleared for the admission of the rivets by reaming.

End connection angles, stiffener angles, etc., shall be carefully adjusted to correct locations and rigidly bolted, clamped or otherwise firmly held in place until riveted.

69.68. **Match-Marking:** Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished to the Engineer.

69.69. **Rivets:** The diameter of rivets indicated upon the plans shall be understood to mean their diameter before heating.

Heads of driven rivets shall be of approved shape, concentric with the shanks, true to size, full, neatly formed, free from fins and in full contact with the surface of the member.

69.70. **Field Rivets:** Field rivets, for each size and length, shall be supplied in excess of the actual number to be driven to provide for losses due to misuse, improper driving or other contingencies. Rivets shall be free from furnace scale on their shanks and from fins on the under side of the machine formed heads.

69.71. **Bolts and Bolted Connections:** Bolted connections shall not be used unless specifically authorized. Where bolted connections are permitted the bolts furnished shall be unfinished bolts (ordinary rough or machine bolts) or turned bolts, as specified or directed by the Engineer.

Unfinished Bolts: Unfinished bolts shall be standard bolts with hexagonal heads and nuts. The use of "button head" bolts will not be permitted. Bolts transmitting shear shall be threaded to such length that not more than one thread will be within the grip of the metal. The bolts shall be of lengths which will extend entirely through their nuts but not more than one-quarter (¼) inch beyond them. The diameter of the bolt holes shall be one-sixteenth (1/16) inch greater than the diameter of the bolts used.

Turned Bolts: Holes for turned bolts shall be carefully reamed or drilled and the bolts turned to a driving fit by being given a finishing cut. The threads shall be entirely outside of the holes and the heads and nuts shall be hexagonal. Approved nut-locks shall be used on all bolts unless permission to the contrary is secured from the Engineer. When nut-locks are not used, round washers having a thickness of one-eighth (1/8) inch shall be placed under the nuts.

69.72. **Riveting:** Rivets shall be heated uniformly to a light cherry red color and shall be driven while hot. The heating of the points of rivets more than the remainder will be permitted. When ready for driving they shall be free from slag, scale and other adhering matter and when driven they shall completely fill the holes. Burned, burred or otherwise defective rivets, or rivets which throw off sparks when taken from the furnace or forge shall not be driven.

Loose, burned, badly formed or otherwise defective rivets shall be cut out. Caulking and re-cupping of rivet heads will not be allowed. In cutting out defective rivets care shall be taken not to injure the adjacent metal and, if necessary, the rivet shanks shall be removed by drilling.

Countersinking shall be neatly done and counter-sunk rivets shall completely fill the holes.

Shop rivets shall be driven by direct-acting riveters where practicable. The riveting machine shall retain the pressure for a short time after the upsetting is complete.

Pneumatic hammers shall be used for field riveting except when the use of other hand tools for riveting is permitted by the Engineer.

69.73. **Edge Planing:** Sheared edges of material more than five-eighths (5/8) inch in thickness shall, when required by the Engineer, be planed to a depth of not less than one-eighth (1/8) inch. Reentrant cuts shall be filleted before cutting.

69.74. **Planing of Bearing Surface:** Ends of columns taking bearing upon base and cap plates shall be milled to true surfaces and correct bevels after the main section of these members and the end connection angles have been fully riveted.

Caps and base plates of columns and the sole plates of birders and trusses shall have full contact when assembled. The plates, if warped or deformed, shall be hot-straightened, planed or otherwise treated to secure an accurate, uniform contact. After being riveted in place the excess metal of countersunk rivet heads shall be chipped smooth and flush with the surrounding metal and the surfaces which are to come in contact with other metal surfaces shall be planed or milled, if necessary, to secure proper contact. Correspondingly, the surfaces of base and sole plates which are to come in contact with masonry shall be rough finished, if not free from warps or other deformations.

Surfaces of cast pedestals and shoes which are to come in contact with metal surfaces shall be planed and those which are to take bearing upon the masonry shall be rough finished.

In planing the surfaces of expansion bearings the cut of the tool shall be in the direction of expansion.

Surfaces of bronze bearing plates intended for sliding contact, shall be carefully milled and polish finished.

69.75. **Abutting Joints:** Abutting ends of compression members shall, after the members have been riveted, be accurately faced to secure an even bearing when assembled in the structure.

Ends of tension members at splices shall be rough finished to secure close and neat but not contact fitting joints.

69.76. **End Connection Angles:** End connection angles or floor beams and stringers shall be flush with each other and accurately set as to position and length of member. In general, and connection angles shall not be finished unless required by the terms of the contract. However, faulty assembling and riveting may be cause for requiring them to be milled, in which case their thickness shall be reduced not to exceed one-sixteenth (1/16) inch, nor shall their rivet bearing value be reduced below design requirements.

69.77. **Built Members:** The several pieces forming one built member shall be straight and close fitting. Such members shall be true to detailed dimensions and free from twists, bends, open joints or other defects resulting from faulty fabrication and workmanship.

69.78. **Lacing Bars:** The ends of lacing bars shall be neatly rounded unless otherwise indicated.

69.79. **Plate Girders—Web Plates:** Web plates of girders having no cover plates may be detailed with the top edge of the web flush with the backs of the flange angles. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of angles. Web plates of girders having cover plates may be one-half (½) inch less in width than the distance back to back of flange angles.

When web plates are spliced, not more than three-eighths (3/8) inch clearance between ends of plates will be allowed.

Web Stiffeners: End stiffener angles of girders and stiffner angles intended as supports for concentrated loads shall be milled or ground to secure a uniform, even bearing against the flange angles. Intermediate stiffener angles shall fit sufficiently tight to exclude water after being painted.

Web Splices and Fillers: Web splice plates and fillers under stiffeners shall fit within one-eighth (1/8) inch at each end.

69.80. **Eye-Bars:** Eye-bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect affecting their service strength. Heads shall be made by upsetting, rolling or forging. Welds in the body portions or in the heads of bars will not be permitted. The form of the heads may be determined by the dies in use at the works where the eye-bars are to be made, if satisfactory to the Engineer. The thickness of head and neck shall not overrun more than one-sixteenth (1/16) inch.

Boring: Before boring, each eye-bar shall be properly annealed and carefully straightened. Pin holes shall be located on the center line of the bar and in the centers of the heads. The holes in the ends of bars shall be bored simultaneously and shall be so accurately located that when the bars of the same truss panels are placed in a pile the pins may be completely inserted in the pin-holes without driving. All eye-bars intended for the same locations in the trusses shall be interchangeable.

69.81. **Annealing:** All eye-bars shall be annealed by heating uniformly to the proper temperature followed by slow and uniform cooling in the furnace. The temperature of the bars shall be under full control at all stages.

Forged pins, and other steel parts requiring their full strength, which have been partially heated shall be subsequently annealed. Slight bends in pieces of secondary importance may be made without heating the metal. Crimped web stiffeners need not be annealed.

69.82. **Pins and Rollers:** Pins and rollers shall be accurately turned to detailed dimensions and shall be smooth, straight and free from flaws. The final surface shall be produced by a finishing cut.

Forged Pins: Pins having a dimater greater than six (6) inches shall be forged and annealed.

Bored Pins: Pins larger than eight (8) inches in diameter shall have a hole not less than two (2) inches in diameter bored longitudinally through their centers. Pins showing defective interior conditions shall be rejected.

69.83. **Boring Pin Holes:** Pin holes shall be bored true to detailed dimensions, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. A finished cut shall always be made.

The length outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from detailed dimensions more than one-thirty-second (1/32) inch. Boring of holes in built up members shall be done after the riveting is completed.

69.84. **Pin Clearances:** The difference in diameter between the pin and the pin hole shall be not more than one-thirty-second (1/32) inch.

69.85. **Welds:** Welding of steel shall not be permitted except to remedy minor defects and then only with the approval of the Engineer.

69.86. **Screw Threads:** Screw threads shall make close fits in the nuts and shall be U. S. Standard, except that for diameters greater than one and one-half (1½) inch, they shall be made with six (6) threads to the inch.

69.87. **Pilot and Driving Nuts:** Two pilot nuts and two driving nuts shall be furnished for each size of pin, unless otherwise specified.

MILL AND SHOP INSPECTION

69.88. **Notice of Rolling and Fabrication:** The Contractor shall give ample notice to the Engineer of the beginning of work at the mill and shop, so that inspection may be provided. No material shall be rolled or fabricated before the Engineer has been notified where the orders have been placed.

69.89. **Facilities for Inspection:** The Contractor shall furnish all facilities for the inspection of material and workmanship in the mill and shop and Inspectors shall be allowed free access to the necessary parts of the premises.

69.90. **Inspector's Authority:** The Inspector shall have the power to reject materials or workmanship which do not fulfill the requirements of these specifications; but in cases of dispute the Contractor may appeal to the Engineer, whose decision shall be final.

Inspection at the mill and shop is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it will not relieve the Contractor from any responsibility in regard to imperfect material or workmanship and the necessity for replacing the same.

69.91. **Mill Orders and Shipping Statements:** The Contractor shall furnish the Engineer with as many copies of mill orders and shipping statements as the Engineer may direct. The weights of the individual members shall be shown.

69.92. **Cost of Testing:** Unless otherwise provided, the Contractor shall furnish without charge, test specimens as specified herein, and all labor, testing machines and tools necessary to prepare the specimens and to make the full-size tests.

69.93. **Rejections:** The acceptance of any material or finished members by the Inspector shall not be a bar to their subsequent rejection, if found defective. Rejected material and workmanship shall be replaced promptly or made good by the Contractor.

69.94. **Marking and Shipping:** Members weighing more than three (3) tons shall have the weight marked thereon. Bolts and rivets of one length and diameter and loose nuts or washers of each size, shall be packed separately. Pins, small parts, and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed three-hundred (300) pounds. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

The weight of all tools and erection material shall be kept separate.

Anchor-bolts, washers, and other anchorage or grillage materials, shall be shipped to suit the requirements of the masonry construction.

Loading and Unloading: The loading, transportation, unloading and piling of structural material shall be so conducted that the metal will be kept clean and free from injury by rough handling.

ERECTION

69.95. **Field Inspection:** All work of erection shall be subject to the inspection of the Engineer who shall be given all facilities required for a thorough inspection of workmanship.

Material and workmanship not previously inspected will be inspected after its delivery to the site of the work.

69.96. **Storage:** All material shall be stored in such manner as to prevent deterioration by rust or loss of minor parts. No material shall be piled so as to rest upon the ground or in water but must be placed on suitable skids or platforms.

69.97. **Preparation of Bearing Area:** Column bases, truss and girder pedestals and shoes shall have a full and uniform bearing upon the substructure masonry. Masonry bearing plates shall not be placed upon the bridge seat areas of piers or abutments which are improperly finished, deformed or irregular.

The shoes and pedestals of truss and girder spans, the bases of columns, and the center and end bearings of swing spans shall be rigidly and permanently located to correct alignments and elevations. Unless otherwise provided they shall be placed on a layer of canvas and red lead applied as follows:

Thoroughly swab the top surface of the bridge seat bearing area with red lead paint and place upon it three layers of twelve (12) ounces to fourteen (14) ounces duck, each layer being thoroughly swabbed on its top surface with red lead paint. Place in position the superstructure shoes or pedestals while the paint is plastic.

69.98. **Handling Members:** The field assembling of the component parts of a structure shall involve the use of methods and appliances not likely to produce injury by twisting, bending or otherwise deforming the metal. No member slightly bent or twisted shall be put in place until its defects are corrected, and members seriously damaged in handling shall be rejected.

69.99. **Alignment:** Before beginning the field riveting the structure shall be adjusted to correct grade and alignment and the elevation of panel points (ends of floorbeams) properly regulated. For truss spans a slight excess camber will be permitted while the bottom chords are being riveted, but the correct camber and relative elevations of panel points shall be secured before riveting the top chord joints, top lateral system and sway bracing.

69.100. **Straightening Bent Material:** The straightening of bent edges of plates, angles and other shapes shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted by the Engineer, in which case the heating shall not be to a higher temperature than that producing a dark cherry red color. After heating, the metal shall be cooled as slowly as possible.

Following the completion of the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of incipient or other fractures.

69.101. **Assembling and Riveting:** All field connections and splices shall be securely drift-pinned and bolted before riveting. Important connections in trusses, girders, floor system, etc., shall at least have fifty (50) per cent of the holes filled. An ample number of drift pins shall be used to prevent slipping at joints and splices.

The results obtained in the field assembling and riveting of the members of a structure shall conform to the requirements for shop assembling and riveting. Field driven rivets shall be inspected and accepted before being painted.

Field riveting of tension chord members shall be done before the false work is removed; but compression chord members shall not be riveted until the span is released sufficiently from the false work to bring the compression chord joints into full bearing.

Railings shall not be riveted until the false work is removed.

69.102. **Adjustment of Pin Nuts:** All nuts on pins shall be thoroughly tightened and the pins so located in the holes that the members shall take full and even bearing upon them.

69.103. **Setting Anchor Bolts:** Anchor bolt holes shall be drilled in correct locations vertically to the plane of the bridge seat, and the anchor bolts set in Portland cement mortar therein. The mortar shall consist of one part cement to one part clean, fine grained sand mixed sufficiently wet to flow freely.

Anchor bolts shall be first dropped into the dry holes to assure their proper fit after setting. They shall then be set as follows:

Fill the hole about two-thirds full of mortar and by a uniform, even pressure or by light blows with a hammer, (flogging and ramming will not be permitted) force the bolt down until the mortar rises to the top of the hole and the anchor bolt nut rests firmly against the metal shoe or pedestal. Remove all excess mortar which may have flushed out of the hole, to permit proper field painting of the metal surfaces.

The location of the anchor bolts in relation to the slotted holes in expansion shoes shall be varied with the prevailing temperature. The nuts on anchor bolts at the expansion ends of spans shall permit the free movement of the span.

Anchor bolts which are to be set in the masonry prior to the erection of the superstructure shall be carefully set to proper location and elevation with templets or by other suitable means.

PAINTING

69.104. **General Conditions:** The painting of metal structures shall include, unless otherwise provided in the contract, the proper preparation of the metal surfaces, the application, protection and curing of the paint coatings, the protection of pedestrains, vehicular or other traffic upon or underneath the bridge structure, the protection of all portions of the structure (superstructure and substructure) against disfigurement by spatters, splashers and smirches of paint or of paint materials, and the supplying of all tools, tackle, scaffolding, labor, workmanship and materials necessary for the entire work. Materials to conform to the requirements set forth in Paragraphs 69.25 to 69.50.

APPLICATION OF PAINT

69.105. **Number of Coats.** All new structural steel work shall, unless otherwise especially provided upon the plans or in the contract, be painted three coats of paint. The first coat is to be applied immediately after the shop fabication is complete except that all surfaces coming into contact are to be painted before being assembled. The second and third coats are to be applied after all erection is complete, except that immediately following the field riveting of the members, the heads of filed rivets, and all abrasions of the shop coat due to handling at the shop, shipment, erection, etc., and all field erection marks shall be thoroughly covered with one coat of shop paint and permitted to become thoroughly dry before the first field coat is applied.

69.106. **Colors of Coats:** The color of each succeeding coat shall be sufficiently different from that previously applied to readily permit the discovery of an incomplete application of the paint coat. The colors of the coats shall be determined by the Engineer.

69.107. **Weather Conditions:** Paint shall be applied only when the air temperature is at or above forty degrees Fahrenheit (40 degrees F.). It shall not be applied upon damp surfaces or upon metal containing frost, nor shall it be applied when the air is misty, or otherwise, in the opinion of the Engineer, unsatisfactory for the work.

Material painted under cover in damp or cold weather shall remain under cover until dry or until weather conditions permit its exposure in the open. Painting in open yards or upon erected structures shall not be done when the metal has absorbed sufficient heat to cause the paint to blister and produce a porous paint film.

69.108. **Application:** No wide, flat brushes shall be used. All brushes shall be either round or oval in shape.

The paint when applied shall be so manipulated under the brush as to produce a uniform even coating in close contact with the metal or with previously applied paint. In general, the primary movement or the brush shall describe a series of small circles to thoroughly fill all irregularities in the surface, after which the coating shall be smoothed and thinned by a series of parallel strokes.

To secure a maximum thickness of paint film upon rivet heads, and edges of plates, angles or other rolled shapes these areas shall be "striped" in advance of the general painting, and shortly afterward shall be given a second or "wash" coat when the general coat is applied. The paint shall be well worked into all joints and open spaces.

Paint shall be thoroughly stirred preferably by means of mechanical mixers before being removed from the containers, and to keep the pigments in suspension shall be kept stirred while being applied.

All painting must be done in a neat and workmanlike manner.

On all surfaces which are inaccessible for paint brushes, the paint shall be applied with sheepskin daubers specially constructed for the purpose.

69.109. **Removal of Improper Paint:** All metal coated with impure or unauthorized paint shall be thoroughly cleaned and repainted to the satisfaction of the Engineer, at the expense of the Contractor.

69.110. **Thinning:** If it is necessary in cool weather to thin the paint in order that it shall spread more freely, this shall be done only by heating in hot water or on steam radiators.

SHOP PAINTING STEEL STRUCTURES

69.111. **Shop Cleaning:** All surfaces of metal to be painted shall be thoroughly cleaned of rust, loose mill scale, dirt, oil or grease, and all other foreign substances. The removal of rust, scale and dirt shall generally be done by the use of metal brushes, scrapers, chisels, hammers or other effective means. Oil and grease may be removed by the use of gasoline or benzine. Bristle or wood fibre brushes shall be used for removing loose dust.

69.112. **Shop Painting:** Surfaces to be riveted in contact either in the shop or field shall not be painted. Surfaces not in contact, but which will be inaccessible after assembly or erection, shall be painted two coats.

When all fabrication work is complete and has been accepted as such, all surfaces not painted before assembling shall be painted a good shop coat. Materials shall not be loaded for shipment until thoroughly dry. No painting shall be done after loading material on cars.

69.113. **Erection Marks**: Erection marks for the field identification of members shall be painted upon previously painted surfaces.

69.114. **Machine Finished Surfaces:** With the exception of abutting chord and column splices, column and truss shoe bases, machine finished surfaces shall be coated as soon as practicable after being accepted, with a hot mixture of white lead and tallow before removal from the shop. Surfaces of iron and steel castings milled for the purpose of removing scales, scabs, fins, blisters or other surface deformations shall generally be given the shop coat of paint.

The composition used for coating machine finished surfaces shall be mixed in the following proportions:

4 lbs. pure tallow.
2 lbs. pure white lead.
1 qt. linseed oil.

FIELD PAINTING STEEL STRUCTURES

69.115. **Field Cleaning:** When the erection work is complete including all riveting, straightening of bent metal, etc., all adhering rust, scale, dirt, grease or other foreign matter shall be removed as specified under Shop Cleaning, Paragraph 69.111.

69.116. As soon as the field cleaning is done to the satisfaction of the engineer the heads of field rivets and bolts and any surfaces from which the shop coat of paint has become worn off or has otherwise become defective and all shipping and erection marks shall be thoroughly covered with one coat of the same paint as used in the shop and permitted to become thoroughly dry before the first field coat is applied.

When the paint applied for "touching up" rivet heads and abraded surfaces has become thoroughly dry the first and second field coats may be applied. In no case shall a succeeding coat be applied until the previous coat has dried throughout the full thickness of the paint film.

All small cracks and cavities which have not become sealed in a watertight manner by the first field coat shall be filled with a pasty mixture of red lead and linseed oil before the second field coat is applied.

MAINTENANCE PAINTING STEEL STRUCTURES

69.117. **Scope of Work:** Unless otherwise provided maintenance painting shall consist of the removal of the rust, scale, dead paint, dirt, grease or other foreign matter from the metal parts or portions of existing bridge structures and the application of paint thereto.

All metal surfaces not in close contact with other metal surfaces or with wooden floor or truss members, concrete, stone masonry, etc., shall be considered as exposed to deterioration by rusting and shall be thoroughly cleaned and painted the number of coats indicated in and made a part of the contract.

69.118. **Number of Coats:** Unless otherwise provided, metal after being cleaned to the satisfaction of the Engineer shall be painted at least two coats of paint.

69.119. **Cleaning and Painting:** The requirements and methods of procedure for maintenance cleaning and painting shall be the same as specified for shop and field painting.

Whenever roadway or sidewalk planking is laid too closely in contact with the metal to permit free access for proper cleaning and painting, the planks shall either be removed or shall be cut to provide at least a one inch clearance for that purpose. The removal or the cutting of planks shall be done as directed by the Engineer. All planks removed shall be satisfactorily replaced and if broken or otherwise injured to an extent rendering them unfit for use they shall be renewed at the expense of the Contractor.

MEASUREMENTS AND PAYMENTS

69.120. **Basis of Payment:** The contract price for fabrication and erection of structural steel shall include all labor, material, transportation and painting necessary for the proper completion of the work.

Payment will be made on a pound-price or a lump sum basis, as required by the terms of the contract. For the purpose of payment, such minor items as bearing plates, pedestals, etc., shall, unless otherwise provided, be considered as structural steel even though made of other materials.

Payment for all material used in full-size tests shall be made on a pound-price basis or pound-price contracts, and, unless otherwise provided, on a basis of actual cost plus ten (10) per cent for lump-sum contracts. The scrap value of all material tested to destruction shall be allowed as a credit upon such payments.

69.121. **Weight Paid For:** The payment for pound-price contracts shall be based on the weight of metal in the fabricated structure, including field rivets shipped. The weight of erection bolts, field paint, and all boxes, crates or other containers used for packing, together with sills, struts and rods used for supporting members during transportation, shall be excluded.

Weights paid for shall be shop-scale weights unless otherwise provided. If specified in the contract or permitted by the Engineer, computed weights as hereinafter provided may be made the basis of payment.

69.122. **Variation in Weight:** If the weight of any member is more than two (2) per cent less than the computed weight, it may be cause for rejection. This applies to both pound-price and lump-sum contracts.

If the total scale weight of any structure exceeds the computed weight by more than two (2) per cent, the weight in excess of two (2) per cent above the computed weight shall not be paid for.

69.123. **Weighing of Members:** Finished work shall be weighed in the presence of the Inspector, if practicable. The Contractor shall supply satisfactory scales and shall perform all work involved in handling and weighing the various parts.

69.124. **Computed Weight:** The weight of steel shall be assumed at four hundred and ninety (490) pounds per cubic foot. The weight of cast iron shall be assumed at four hundred and fifty (450) pounds per cubic foot.

The weights of rolled shapes, and of plates up to and including thirty-six (36) inches in width, shall be computed on the basis of their nominal weights and dimensions, as shown on the approved shop drawings, deducting for copes, cuts and open holes.

The weights of plates wider than thirty-six (36) inches shall be computed on the basis of their dimensions, as shown on the approved shop drawings, deducting for cuts and open holes. To this shall be added one-half of the allowed percentages of overrun in weight given in the Standard Specifications for Structural Steel for Bridges, Serial Designation A7-24, of the American Society for Testing Materials.

The weight of heads of shop driven rivets shall be included in the computed weight, assuming the weights to be as follows:

Diameter of Rivet	Weight for 100 heads
½ inch	4.0 pounds
5/8 inch	7.5 pounds
¾ inch	12.5 pounds
7/8 inch	18.5 pounds
1 inch	27.0 pounds

The weight of casting shall be computed from the dimensions shown on the approved shop drawings, with an addition of ten (10) per cent for fillets and overrun.

To the total computed weight of metal may be added an allowance of four-tenths (0.4) of one per cent for shop paint.

Payment will be made under
Item No. 72, Structural Steel (per pound).
Item No. 73, Structural Steel Superstructure complete except floor (lump sum).

SECTION 70

TIMBER STRUCTURES

70.01. **Description:** All timber structures shall be built as indicated on the plans, conforming to the line grade and dimensions shown, and in accordance with the specifications for Piling, Concrete, Untreated Timber, Treated Timber, and other items which constitute the complete structure.

MATERIALS

70.02. **Lumber and Timber:** For the various structural purposes the following grades shall be used. Southern long leaf yellow pine timber shall be used unless otherwise specified.

(a) Truss members, floor beams, stringers and flooring shall be Dense Select Structural or Select Structural, as specified. Flooring, if untreated shall be thoroughly air seasoned or kiln dried.

(b) Caps, posts, sills and mud sills, and nailing strips shall be Select Structural or Common Structural, as specified.

(c) Guard timbers and retaining pieces; sash, cross and longiutdinal bracing; and girts shall be Common Structural.

(d) Bulkheads shall be Common Structural or No. 1 Common, as specified.

(e) Rails, rail posts and truss housing shall be Grade D Select or No. 1 Common, as specified. Rails and rail posts, if untreated, shall be thoroughly air seasoned or kiln dried.

(f) Scupper blocks and cross bridging shall be No. 1 Common.

(g) Inside sheathing for truss housing shall be No. 1 or No. 2 Common, as specified.

(h) For temporary structures which are for use only during erection, members specified above to be of the Dense Select and Select Structural Grades may be of the Common Structural Grade. Members specified above to be of the Common Structural Grade may be of No. one (1) Common.

STRUCTURAL TIMBER LUMBER AND PILING

70.03. **Species of Woods:** The common and botanical names of the species of woods recognized in these specifications are defined as follows:

Common Name	Botanical Name
Chestnut	Castanea dentata
Cypress, Southern	Taxodium distichum
Fir, Douglas	Pseudotsuga taxifolia (Coast type)
Gum,Black	Nyssa sylvatica
Oak, Red includes Red Oak	Quercus borealis and Quercus borealis manima
Black Oak	Quercus velutina
Southern Red Oak	Quercus rubra
Water Oak	Quercus nigra
Willow Oak	Quercus phellos
Scarlet Oak	Quercus cocoinea
Pin Oak	Quercus palustris
Swamp Red Oak	Quercus rubra pagadadfolia
Blackjack Oak	Quercus marilandica
Laurel Oak	Quercus laurifolia
Oak, White includes White Oak	Quercus alba
Chestnut Oak	Quercus montana
Post Oak	Quercus stellata

Bur Oak	Quercus macrocarpa
Overcup Oak	Quercus lyrate
Swamp Chestnut Oak	Quercus prinus
Swamp White Oak	Quercus bicolor
Live Oak	Quercus virginiana
Chinquapin Oak	Quercus muehlenbergii
Pine, Southern Yellow includes	
Loblolly Pine	Pinus taeda
Longleaf Pine	Pinus palustris
Pitch Pine	Pinus rigida
Pond Pine	Pinus serotina
Shortleaf Pine	Pinus echinata
Slash Pine	Pinus caribaea

70.04. **Limitation of Use:** Timbers of the following species shall not be used in exposed structures without preservative treatment:

The red oaks, black gum, and shortleaf, loblolly and pond pine.

LUMBER AND STRUCTURAL TIMBER

70.05. **Heart Requirements:** All timber to be used without preservative treatment shall show not less than the following amounts of heartwood:

Stringers, floorbeams and flooring: Eighty per cent (80%) of heart on any girth.

Caps, sills and posts: Seventy-five per cent (75%) of heart on each of the four sides measured across the side.

Bracing, struts, rails, etc.: Eighty per cent (80%) of heart on both sides measured across the side.

For timber which is to be pressure treated with creosote oil there shall be no heartwood requirement and the amount of sap wood shall not be limited.

70.06. **Grading of Lumber and Timber:** Yard lumber and structural timber shall be graded in accordance with grading rules, adopted by the regional associations of lumber manufacturers, which conform to the basic provisions of "American Lumber Standards."

Lumber ordered in multiple lengths shall be graded after having been cut to length.

70.07. **Basic Grades of Lumber and Timber:** The grades recognized by this specification are as follows:

70.08. **Yard Lumber:** Grade D Select—Allows any number of defects or blemishes which do not detract from a finish appearance, especially when painted.

No. 1 Common—Sound and tight knotted stock.
Size of defects and blemishes limited.
May be considered watertight lumber.

No. 2 Common—Allows large and coarse defects.
May be considered grain-tight lumber.

70.09. **Structural Timber:** Dense select (Douglas Fir and Southern Yellow Pine only.)
Select.

Common—The structural grades are further divided, on the basis of use, size and defects, into the following subgrades:

Joist and Plank
Beam and Stringer
Post and Timber

BASIC GRADING OF STRUCTURAL TIMBER

70.10. **General Provisions:**

(a) All grades shall contain only sound wood.

(b) The measurement of a knot shall be made on the section of the knot appearing on the surface under consideration.

(c) In Post and Timber grades and on the wide faces of Joist and Plank, the measure of a knot shall be on the mean or average diameter.

(d) On the narrow faces of Joist and Plank, and Beams and Stringers, the size of a knot shall be taken as its width between lines parallel to the edges of the timber.

(e) On the wide or vertical faces of Beams and Stringers, the smallest diameter of a knot shall be taken as its size.

(f) Knots on the edges of wide faces of Beams and Stringers are limited to the same size as on the adjacent narrow faces.

(g) Knots on narrow faces and edges of wide faces of Joist and Plank, and Beams and Stringers, may increase proportionately from the size allowed in the middle third to twice that size at the ends of the piece.

(h) The size of knots on the wide faces of Joist and Plank, and Beams and Stringers, may increase proportionately from the size allowed at the edge to that allowed at the center line.

(i) Cluster knots and knots in groups are not permitted.

(j) Knot holes and holes from other causes than knots shall be limited as provided for knots.

(k) Shake shall be measured on the ends of a piece, and its size shall be taken as its width between lines parallel to the wide faces of the piece. Checks and splits shall be limited as provided for shakes. No checks or combinations of checks with shakes which would reduce the strength to a greater extent than the allowable shake shall be permitted.

(l) No combination of wane and knots is permitted which would reduce the strength more than the maximum allowable knot.

(m) No pieces of exceptionally light weight shall be permitted in any grade, except that light weight pieces otherwise of Select Grade may be accepted in the Common Grade.

70.11. **Selection for Close Grain:** Douglas Fir and Southern Yellow Pine of the Select Grade shall be selected for close grain.

Douglas Fir or Southern Yellow Pine selected for close grain shall average on either one end or the other not less than six (6) nor more than twenty (20) annual rings per inch, measured over a three-inch portion of a radial line representative of the average growth on the cross section located as described below.

When such radial line is not representative, it shall be shifted sufficiently to present a fair average, but in boxed heart pieces the distance from the pith to the beginning of the three-inch portion of the line shall not be changed.

In case of disagreement two radial lines shall be closed, and the number of rings shall be the average of these lines.

Location of Radial Line

70.12. **Douglas Fir:** In side cut pieces the line shall be at a right angle to the annual rings and the center of the three (3) inch portion of the line shall be at the center of the end of the piece.

In boxed heart pieces the line shall run from the pith to the corner farthest from the pith. When the least dimension is six (6) inches or less the three (3) inch portion of the line shall begin at a distance of one (1) inch from the pith. When the least dimension is more than six (6) inches the three (3) inch portion of the line shall begin at a distance from the pith equal of two (2) inches less than one-half (½) the least dimension of the piece.

If a three (3) inch portion of the radial line cannot be obtained the measurement shall be made over as much of the three (3) inch portion as is available.

70.13. **Southern Yellow Pine:** In boxed heart pieces the rate of growth shall be counted over the third, fourth, and fifth inches from the pith along the radial line.

In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over three inches on an approximate radial line beginning at the edge nearest the pith in timbers over three (3) inches in thickness and on the second inch nearest to the pith in timbers three (3) inches or less in thickness.

In material containing the pith but not a five (5) inch radial line, which is less than two (2) inches by eight (8) inches in section or less than eight (8) inches in width, that does not show over sixteen (16) square inches on the cross-section, the inspection shall apply to the second inch from the pith. In larger material that does not show a five (5) inch radial line, the inspection shall apply to the three (3) inches farthest from the pith.

70.14. **Selection for Density:** Douglas Fir and Southern Yellow Pine of the Dense Select Grade shall be selected for density.

Douglas Fir or Southern Yellow Pine selected for density shall average on either one end or the other not less than six annual rings per inch and in addition one-third, or more, summerwood, over the same portion of a radial line as provided for selection for close grain. Coarse-grained material excluded by this rule shall be accepted as dense if averaging one-half, or more, summerwood.

The contrast in color between summerwood and springwood shall be sharp and the summerwood shall be dark in color, except in pieces having considerably above the minimum requirement for summerwood.

In case of disagreement two radial lines shall be chosen and the summerwood and number of rings shall be the average of these lines.

70.15. **Joist and Plank Grades:** Nominal thicknesses: 2 inch to 4 inch.

Nominal widths: 4 inch and wider.
Standard thicknesses, S1S or S2S: 3/8 inch off.
Extra Standard Thickness, 2 inch, S1S or S2S: ¼ inch off.
Standard Widths, 2 inches to 7 inches, S1E or S2E: 3/8 inch off.
8 inches and wider, S1E or S2E: ½ inch off.
Standard Lengths: Multiples of two feet.

KNOTS ON WIDE FACES

Width of Face	Dense Select	Select	Common	
	On or near edge middle third of length	Center line of face	On or near edge middle third of length	Center line of face
4″	3/4″	1-1/4″	1″	1-3/4″
6″	1″	2″	1-1/2″	2-1/2″
8″	1-3/8″	2-5/8″	2″	3-3/8″
10″	1-3/4″	3-1/4″	2-1/2″	4-1/4″
12″	2-1/8″	4″	3″	5-1/8″
14″	2-3/8″	4-1/4″	3-1/4″	5-5/8″
16″	2-1/2″	4-5/8″	3-3/8″	6″

KNOTS ON NARROW FACES OF BOXED HEART PIECES MIDDLE THIRD OF LENGTH

Thickness of piece	Size of Knot	
	Select	Common
2″	5/8″	7/8″
3″	1″	1-1/4″
4″	1-1/4″	1-3/4″

SUM OF DIAMETERS OF KNOTS, IN CENTER HALF OF LENGTH ON ANY FACE, NOT TO EXCEED

Dense Select—Select
1½ times width of face.

Common
Two times width of face.

SHAKES AND CHECKS

Dense Select—Select
Green 1/4 width of end
Seasoned 1/3 width of end

Common
4/10 width of end
4/9 width of end

ANGLE OF GRAIN, CENTER HALF OF LENGTH

Dense Select—Select
1 in 12

Common
1 in 10

WANE

Dense Select—Select
1/8 thickness and/or width

Common
1/4 thickness and/or width

70.16. **Beam and Stringer Grades:**
Nominal thicknesses: 5 inch and thicker.
Standard lengths: Multiples of two feet.
Nominal widths: 8 inches and wider.
S1S, S1E, S2S or S4S: ½ inch off each way.

KNOTS

Width of Face	Dense Select	Select	Common	
	Narrow face and edge of wide face middle third of length	Center line of wide face	Narrow face and edge of wide face middle third of length	Center line of wide face
5″	1-1/4″	....	2″	....
6″	1-1/2″	1-1/2″	2-3/8″	2-3/8″
8″	1-3/4″	2″	2-3/4″	3-1/8″
10″	2″	2-1/2″	3-1/8″	4″
12″	2-1/8″	3″	3-3/8″	4-3/4″
14″	2-1/4″	3-1/4″	3-5/8″	5-1/8″
16″	2-3/8″	3-3/8″	3-7/8″	5-1/2″
18″	....	3-5/8″	....	5-7/8″
20″	....	3-7/8″	....	6-1/8″
22″	....	4″	....	6-1/2″
24″	....	4-1/4″	....	6-3/4″

SUM OF DIAMETERS OF KNOTS, IN CENTER HALF OF LENGTH ON ANY FACE, NOT TO EXCEED

Dense Select—Select	Common
Width of Face	1½ times width of face

SHAKES AND CHECKS

Dense Select—Select	Common
Green 1/4 width of end	4/10 width of end
Seasoned 1/3 width of end	4/9 width of end

ANGLE OF GRAIN, CENTER HALF OF LENGTH

Dense Select—Select	Common
1 in 15	1 in 10

WANE

Dense Select—Select	Common
1/8 thickness and/or width	¼ thickness and/or width

70.17. **Post and Timber Grades:** (**Note:** The method of measuring knots in the Post and Timber Grades makes it impractical to assign bending stresses to these grades. Therefore square timbers to be used where strength in bending is a factor shall be graded as Beams and Stringers)

Nominal sizes: 6 inches x 6 inches and larger.
Standard lengths: Multiple of two feet.
S1S, S1E, S2S, or S4S: ½ inch off each way.

KNOTS

Width	Size of Knots	
Width of Face	Dense Select and Select	Common
6″	1-1/2″	2-3/8″
8″	2″	3-1/8″
10″	2-1/2″	4″
12″	3″	4-3/4″
14″	3-1/4″	5-1/8″
16″	3-3/8″	5/1-2″
18″	3-5/8″	5-7/8″
20″	3-7/8″	6-1/8″
22″	4″	6-1/2″
24″	4-1/4″	6-3/4″

The sum of diameters of all knots within any six (6″) of length shall not exceed twice the size of the maximum knot allowable; nor shall there be two of the maximum allowable knots in the same six (6″) of length on any one face.

SHAKES AND CHECKS

Dense Select—Select	Common
Green 4/10 width of end	1/2 width of end
Seasoned 1/2 width of end	6/10 width of end

ANGLE OF GRAIN

Dense Select—Select	Common
1 in 10	1 in 8

WANE

Dense Select—Select	Common
1/8 thickness and/or width	1/4 thickness and/or width

70.18. **Hewn and Round Timber:** Hewn timbers used in place of sawed timbers shall conform in all respects to the grading rules for Structural Timber.

Round timbers used in place of sawed timbers shall be of a quality equal to that hereinafter specified for Timber Piles. Section 75.

The effective size of a round timber shall be considered the same as that of a square timber having sectional dimensions equal to those of the inscribed square of the round timber at the critical section.

Hewn and round timbers shall not be used except when specified or approved by the Engineer.

TIMBER PRESERVATIVES

70.19. **Preservative Oils:** The preservative oil used shall be as specified or directed by the Engineer and shall be one of the following, depending on the type of treatment.

The creosote and anthracene oils shall be distillates of coal-gas tar or coke-oven tar. The creosote-coal-tar solution shall be a coal-tar product of which at least eighty (80%) shall be a distillate of coal-gas tar or coke-oven tar, and the remainder shall be refined or filtered coal-gas tar or coke-oven tar.

	PRESSURE TREATMENT				SURFACE TREATMENT (Open Tank, Brush and Spray)	
	Creosote Oils			Creosote-Coal-Tar Solution		
	Gra. 1	Gra. 2	Gra. 3		Anthracene Oil	Hvy. Creosote Oil
(1) It shall not contain water in excess of	3%	3%	3%	3%	1%	1%
(2) It shall be fluid at 15°C. and crystal-free at 38°C.					Required	Required
(3) It shall not contain matter insoluble in benzol in excess of	0.5%	0.5%	0.5%	2%	0.5%	0.5%
(4) The specific gravity at 38°/15.5°C. shall not be less than	1.03	1.03	1.03	1.05 to 1.12	1.09 to 1.13	1.06
(5) The distillate based on water-free oil, shall be within the following limits:						
Up to 210°C., not more than	5%	8%	10%	5%		1%
Up to 235°C., not more than	25%	35%	40%	25%	2½%	10%
Between 235°C., and 300°C., not more than					20%	
Up to 355°C., not less than					50%	65%
(6) The float test of residue above 355°C., shall not exceed 50 seconds at 70°C., if the distillation residue above 355°C., exceeds	5%	5%	5%	26%	35%	10%
(7) Coke residue of oil shall not exceed	2%	2%	2%	6%	2%	2%

70.20. **Zinc Chloride:** Zinc chloride shall be acid-free and shall not contain more than one-tenth (0.1%) iron. Fused or so solid zinc chloride shall contain at least ninety-four (94%) chloride of zinc. Concentrated zinc chloride shall contain at least fifty (50%) chloride of zinc.

70.21. **Sampling and Testing:** Preservative oils shall be sampled and tested in accordance with the "Methods of Sampling and Analyzing Creosote Oil" as provided in the Tentative Standard Methods of Sampling and Testing of the American Association of State Highway Officials (A. S. T. M. Standard Method, Serial Designation D38-18, slightly modified) in so far as this applies, except that the distillation tests of anthracene oil shall be made in accordance with the requirements of the standard specifications of the American Wood Preservers' Association. Coke residue shall be determined in accordance with the Tentative Method of Test for Coke Residue of Creosote Oil, Serial Designation on D168-23T, of the American Society for Testing Materials.

Zinc chloride shall be tested in accordance with the Tentative Methods of Chemical Analysis of Zinc Chloride, Serial Designation D199-24T, of the American Society for Testing Materials.

70.22. **Structural Shapes:** Rods, plates and shapes shall be of structural steel or wrought-iron as specified, conforming to the requirements of Section 69. Eyebars shall conform to the requirements of Section 69, for structural steel eye-bars.

70.23. **Castings:** Castings shall be cast steel or gray-iron as specified, conforming to the requirements of Section 69, paragraphs 69.16 to 69.20, inclusive.

70.24. **Hardware:** Machine bolts, drift bolts and dowels may be either wrought-iron or medium steel. Washers may be cast O-gee or malleable castings, or may be cut from medium steel or wrought-iron plate, as specified.

Machine bolts shall have square heads and nuts unless otherwise specified. Nails shall be cut or round wire of standard form. Spikes shall be cut or wire spikes, or boat spikes, as specified.

Nails, spikes, bolts, dowels, washers and lag screws shall be black or galvanized, as specified.

70.25. **Paint:** All paint for timber structures shall conform to the requirements specified in Section 69 as regard to quality and shall conform in composition to the formulas in paragraphs 69.30, 69.46c or 69.46d. Unless specially provided paint provided in paragraph 69.46d shall be used on all timber.

CONSTRUCTION METHODS

70.26. **Storage of Material:** Lumber and timber on the site of the work shall be stored in piles.

Untreated material shall be open-stacked at least twelve (12) inches above the ground surface, and piled to shed water and prevent warping. When required by the Engineer it shall be protected from the weather by suitable covering.

Creosoted timber and piling shall be close stacked, piled to prevent warping, and the tops of the stacks shall be covered with a two (2) inch layer of earth.

The ground underneath and in the vicinity of all material piles shall be cleared of weeds and rubbish.

70.27. **Workmanship:** Workmanship shall be first-class throughout. None but competent bridge carpenters shall be employed and all framing shall be true and exact. Nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship and sufficient cause for the removal of the workman causing them. The workmanship on all metal parts shall conform to the requirements specified for Steel Structures, Section 69.

70.28. **Treated Timber: Handling.** Treated timber shall be carefully handled without sudden dropping, breaking of outer fibers, bruising or penetrating the surface with tools. It shall be handled with rope slings. Cant dogs, peaveys, hooks or pike-poles shall not be used.

Framing and Boring: All cutting, framing and boring of treated timber shall be done before treatment in so far as is practicable. In waters infested by marine borers, cutting and boring below high water shall be avoided.

Cuts and Abrasions: All cuts in treated piles or timbers, and all abrasions after having been carefully trimmed, shall be covered with two applications of a mixture of sixty (60) per cent creosote oil and forty (40) per cent roofing pitch or brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch.

Bolt Holes: Before driving bolts, hot creosote oil shall be poured into all bolt holes in such a manner that the entire surface of the hole shall be thoroughly coated with the oil. Any unfilled holes, after being treated with creosote oil, shall be plugged with creosote plugs.

70.29. **Untreated Timber:** In structures of untreated timber the following surfaces shall be thoroughly coated with hot creosote oil before assembling: Ends, tops and all contact surfaces of sills, caps, floor beams and stringers; and all ends, joints, and contact surfaces of bracing and truss members. The back faces of bulkheads and all other timber which is to be in contact with earth shall be similarly treated.

Bolts passing through non-resinous wood shall preferably be galvanized.

70.30. **Treatment of Pile Heads:** After having been cut to receive the caps, and prior to placing the caps, pile heads shall be treated to prevent decay. The heads of creosoted piles shall be treated as follows:

The sawed surface shall be covered with three applications of a mixture of sixty (60) per cent creosote oil and forty (40) per cent roofing pitch or thoroughly brush coated with three applications of hot creosote oil and covered with hot roofing pitch. Upon this shall be placed, covering of medium-weight roofing felt, or canvas treated with tar and oil, or galvanized iron which shall be bent down over the sides of the pile to shed water, and firmly secured thereto with large headed roofing nails and trimmed to give a workmanlike appearance.

The heads of untreated piles shall be given one of the following treatments as may be specified or directed by the Engineer:

1. The sawed surface shall be thoroughly brush coated with two applications of hot creosote oil.

2. The sawed surface shall be heavily coated with red lead paint after which it shall be covered with cotton duck, of at least eight (8) ounce weight, which shall be folded down over the sides of the pile and firmly secured thereto with large-headed roofing nails. The edges of the duck shall be trimmed to give a workmanlike appearance. The duck shall then be waterproofed by being thoroughly saturated and coated with one or more applications of red lead paint.

70.31. **Holes for Bolts, Dowels, Rods and Lag Screws:** Holes for round drift bolts and dowels shall be bored with a bit one-sixteenth (1/16) inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift bolts or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit of the same diameter as the bolt.

Holes for rods shall be bored with a bit one-sixteenth (1/16) inch greater in diameter than the rod.

Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread

70.32. **Bolts and Washers:** A washer, of the size and type specified, shall be used under all bolt heads and nuts which would otherwise come in contact with wood.

All bolts shall be effectually checked after the nuts have been finally tightened.

70.33. **Countersinking:** Countersinking shall be done wherever smooth faces are required. Recesses formed for countersinking shall be painted with hot creosote oil, and, after the bolt or screw is in place, shall be filled with hot pitch.

70.34. **Framing:** All lumber and timber shall be accurately cut and framed to a close fit in such manner that the joints will have even bearing over the entire contact surfaces. Mortises shall be true to size for their full depth and tenons shall make snug fit therein. No shimming will be permitted in making joints, nor will open joints be accepted.

70.35. **Pile Bents:** The piles shall be driven as accurately as possible in the correct location and to the vertical or batter lines indicated on the plans. In case a pile is driven out of line it shall be straightened without injury before it is cut off or braced. Piles damaged in driving or straightening, or piles driven below grade, shall be removed and replaced at the Contractor's expense. No shimming on tops of piles will be permitted.

The piles for any one bent shall be carefully selected as to size, to avoid undue bending or distortion of the sway bracing.

Cut-offs shall be accurately made to insure perfect bearing between the cap and piles of a bent.

70.36. **FRAMED BENTS**

Mud Sills: Untreated timber used for mud sills shall be of cedar, heart cypress, redwood or other durable timber. Mud sills shall be firmly and evenly bedded to solid bearing and tamped in place.

Concrete Pedestals: Concrete pedestals for the support of framed bents shall be carefully finished so that the sills or posts will take even bearing on them. Dowels or not less than three-fourths (¾) inch diameter and projecting at least six (6) inches above the tops of the pedestals, shall be set in them when they are cast, for anchoring the sills or posts.

Sills: Sills shall have true and even bearing on mud-sills, piles or pedestals. They shall be drift-bolted to mud-sills or piles with bolts of not less than three-fourths (¾) inch diameter and extending into the mud-sills or piles at least six (6) inches. When possible all earth shall be removed from contact with sills so that there will be free air circulation around them.

Posts: Posts shall be fastened to pedestals with dowels of not less than three-fourths (¾) inch diameter extending at least six (6) inches into the posts.

Posts shall be fastened to sills by one of the following methods, as indicated on the plans:

(a) By dowels of not less than three-fourths (¾) inch diameter extending at least six (6) inches into posts and sills.

(b) By drift bolts or not less than three-fourths (¾) inch diameter driven diagonally through the base of the post and extending at least nine (9) inches into the sill.

70.37. **Caps:** Timber caps shall be placed to secure an even and uniform bearing over the tops of the supporting posts or piles and to secure an even alignment of their ends. All caps shall be secured by drift bolts of not less than three-fourths (¾) inch diameter extending at least nine (9) inches into the posts or piles. The drift bolts shall be approximately in the center of the post or piles.

70.38. **Bracing:** The ends of bracing shall be bolted through the pile, post or cap, with a bolt of not less than five-eighths (5/8) inch diameter. Intermediate intersections shall be bolted, or spiked with wire or boat spikes, as indicated on the plans. In all cases spikes shall be used in addition to bolts.

70.39. **Stringers:** Stringers shall be sized at bearings and shall be placed in position so that knots near edges will be in the top portions of the stringers.

Outside stringers may have butt joints but interior stringers shall be lapped to take bearing over the full width of floor beam or cap at each end. The lapped ends of untreated stringers shall be separated at least one-half (½) inch for the circulation of air and shall be securely fastened by drift-bolting where specified. When stringers are two panels in length the joints shall be staggered.

Cross bridging between stringers shall be neatly and accurately framed and securely toe-nailed with at least two nails in each end.

70.40. **Wheel Guards and Railing:** Wheel guards, wheel guard blocks, joist blocks and railing shall be accurately framed in accordance with the plans and erected true to line and grade.

Unless otherwise specified, wheel guards and rails and rail posts shall be surfaced on four (4) sides (S4S.)

Wheel guards shall be laid in sections not less than twelve (12) feet long.

70.41. **Single Plank Floors:** Shall consist of a single thickness of plank supported by stringers or joists, the planks shall be laid heart side down, with one-quarter (¼) inch openings between them or seasoned material and with tight joints for unseasoned material. Each plank shall be spiked to each joist or nailing strip with not less than two spikes, the length of which shall be at least three (3) inches greater than the thickness of the plank. The ends of the planks shall be cut off on a straight line parallel to the center line of the roadway. The planks shall be carefully graded as to thickness and so laid that no two adjacent planks shall vary in thickness any more than one-sixteenth (1/16) inch.

Scupper blocks shall be securely spiked in place, wheel guards shall be laid true to line and grade and bolted through the scupper blocks and floor plank and, if required, through the outside joist or nailing piece.

70.42. **Double Plank Floors:** Double plank floors shall consist of two layers of plank supported on stringers or joists, the lower course of plank shall be pressure treated with creosote oil and shall be laid in the same manner as specified in paragraph 2.15.23 for single plank floors.

The top course of plank shall be laid diagonal or parallel to the center line of roadway, as may be specified and each plank shall be spiked to the lower course at intervals of not more than two (2) feet with two (2) spikes which shall extend into the lower course at least three (3) inches. Joist shall be staggered at least three (3) feet. If the planks are placed parallel to the center line of the roadway, special care shall be exercised to fasten their ends securely and at the ends of the bridge they shall be beveled.

Scupper blocks and wheel guards shall be placed as specified in Paragraph 2.15.23 for single plank floors.

70.43. **Laminated or Strip Floors:** Strip shall not be more than three (3) inches in thickness and shall be surfaced to a uniform thickness (S-1-S) and, when specified, to a uniform width (S-1-E). The strips shall be placed on edge and at right angles to the center line of the roadway. Each strip shall be spiked to the adjacent strip at intervals of two (2) feet, the spikes being staggered eight (8) inches in adjacent strips. The spikes shall be of sufficient length to pass through two (2) strips and at least half-way through the third. In addition the strips shall be toe-nailed to the stringers with 20d spikes, the nailing of successive strips, being staggered so that the spacing of spikes along each stringer shall not be less than six (6) inches. For strips three (3) inches in thickness spikes driven vertically through the strip and extending into the stringer not less than three (3) inches may be substituted for toe-nailing.

70.44. **Trusses:** Trusses, when completed, shall show no irregularities of line. Chords shall be straight and true from end to end in horizontal projection and in vertical projection shall show a smooth curve through panel points conforming to the correct camber. All bearing surfaces shall fit accurately. Uneven or rough cuts at the points of bearing shall be cause for rejection of the piece containing the defect.

70.45. **Truss Housing:** The carpentry on truss housing shall be equal in all respects to the best housework. The finished appearance of the housing is considered of primary importance and special care shall be taken to secure a high quality of workmanship and finish on this portion of the structure. Workmen wearing shoes with calks will not be permitted on the roof.

70.46. **Erection of Trusses:** Unless otherwise directed by the Engineer, the following sequence of operations shall be followed in the erection of trusses:

1. Build trusses.
2. Build floor.
3. Line up trusses and remove supports.
4. Remove falsework.
5. Correct alignment and camber if necessary.
6. Build housing (if required.)
7. Build handrail.
8. Paint.

70.47. **PRESERVATIVE TREATMENTS FOR TIMBER**

SEASONING

70.48. **Air Seasoning:** Materials to be treated preferably shall be air seasoned until the moisture remaining in the wood will not prevent the injection and proper distribution of the specified amount of preservative. For air seasoning, the materials shall be stored as follows: Lumber shall be segregated according to size and each layer in the pile shall be separated by at least one-inch strips with an air space of one inch or more between each two pieces of lumber in any layer; for caps, stringers, posts or large timbers, at least two-inch strips shall be used to separate the layers. Alleys at least three (3) feet wide shall be left between rows of stacks and the material shall be at least twelve (12) inches off the ground on concrete or treated timber sills. Piles shall be stored in like manner, placing as nearly as practical only one length in a stack, using at least two (2) inch strips or saplings of equal size between each layer, and reversing all sticks in every other layer in order to keep the stack level. The space under and between the rows or stacks shall be kept free at all times of rotting wood, weeds or rubbish. The yard shall be so drained that no water can stand under the stacks or in their immediate vicinity.

70.49. **Steam Seasoning for Southern Yellow Pine:** Southern Yellow Pine may be steam seasoned until the moisture remaining in the wood will not prevent the injection and proper distribution of the specified amount of preservative. The material shall be steamed in the cylinder at not more than twenty (20) to twenty-five (25) pounds pressure per square inch for not more than eight (8) hours for sawed timber and not more than twenty (20) hours for piles, the maximum pressure being reached in not less than two (2) hours. The cylinder shall be provided with vents to relieve it of air and insure proper circulation of steam. After steaming is completed a minimum vacuum of twenty-two (22) inches shall be maintained for not less than fifteen (15) minutes, or until the wood is as dry and free from moisture as practicable. The cylinder shall be relieved continuously or frequently enough to prevent condensate from accumulating in sufficient quantity to reach the wood. Before the preservative is introduced the cylinder shall be drained of condensate.

70.50. **Oil Seasoning for Douglas Fir:** Douglas Fir may be seasoned by boiling in oil under a vacuum until the moisture remaining in the wood will not prevent the injection and proper distribution of the specified amount of preservative.

The material shall be boiled in creosote under a vacuum at temperatures which do not exceed two hundred and twenty (220) degrees F. for piling and two hundred (200) degrees F. for sawed timber and lumber. A minimum vacuum of twenty (20) inches shall be maintained during boiling. The seasoning period shall be maintained until condensation passing off from the timber is at the rate of approximately one-tenth (1/10) of a pound per cubic foot of timber per hour.

70.51. **Preparation for Treatment:** Each cylinder charge shall consist of pieces approximately equal in size and moisture and sapwood content, into which approximately equal quantities of preserving fluid can be injected. Pieces shall be so separated as to insure contact of steam and preservatives with all surfaces.

70.52. **Plant Equipment:** Treating plants shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages of treatment, and all equipment shall be maintained in condition satisfactory to the purchaser. The apparatus and chemicals necessary for making the analyses and tests required by the purchaser shall also be provided by plant operators, and kept in condition for use at all times.

70.53. **Penetration:** The range of pressure, temperature, and time duration shall be controlled so as to result in a maximum penetration by the quantity of preservative injected. The vacuum requirements stipulated are in inches of mercury at sea-level, and necessary corrections shall be made for altitude.

In Southern Yellow Pine: The preservative shall permeate all of the sapwood and as much of the heartwood as practicable.

In Douglas Fir the minimum penetration for specified amount of creosote oil shall be as follows:

	Specified amount of creosote per cubic foot.			
	10#	12#	14#	16#
Piling	5/8 inch	¾ inch	7/8 inc	1 inch
Timber 12 inch x 12 inch and larger	.65 inch	.75 inch	.85 inch	1.00 inch

For timbers less than 12 inch x 12 inch the required depth of penetration shall be determined by the formula:

$$P = Ps \frac{R}{Rs}$$

where P = required penetration.
Ps = specified penetration for 12 inch x 12 inch timbers.
R = ratio of volume of the piece in question to its superficial area.
Rs = ratio of volume of 12 inch x 12 inch timber to its superficial area.

The penetration of the preservative shall be based on black or dark oil and in no case will light discoloration of the wood due to treatment be taken into consideration in measuring the depth of penetration.

Tests for penetration shall be made by taking borings with an increment borer or a five-eighth (5/8) inch auger, all holes so bored to be plugged by the Contractor with tight fitting creosoted plugs.

As many penetration tests of lumber and piling shall be made as is considered necessary by the Inspector. In the case of piling, the holes shall be bored midway between the ends.

In the case of timber and lumber, every fourth stick of the charge may be bored.

70.54. **Amount of Preservatives:** The amount of preservative to be used shall be shown on the plans or specified and this amount shall be retained in the timber unless the oil has been injected to refusal. Unless otherwise specified the amount of preservative retained shall be as follows:

(a) **Creosote or Creosote-Coal-Tar:**

1. For piles and timber in general bridge construction:

Full-cell process, not less than twelve (12) lbs. of oil per cubic foot of timber, or empty-cell process, not less than eight (8) lbs. of oil per cubic foot of timber.

2. For piles or timber in salt water subject to attack by Marine borers:

Full-cell process.

Southern Yellow Pine, not less than twenty (20) pounds of oil per cubic foot of timber. Douglas Fir, not less than fifteen (15) pounds of oil per cubic foot of timber.

(b) **Zinc Chloride:**

For timber or lumber to be painted or not subject to water leaching: Not less than one-half (½) pound of dry salt per cubic foot of timber.

PRESSURE TREATMENTS

70.55. **Pressure Treatments for Southern Yellow Pine.** The following pressure processes shall be used for the treatment of Southern Yellow Pine.

(a) **Full-cell Process.** (Oil Treatment.)

Timber shall be subjected to a vacuum of sufficient intensity and duration to insure that the wood is as dry and free from air as practicable, and to permit a retention of the specified number of pounds of preservative per cubic foot of wood.

The preservative shall be introduced between one hundred sixty-five degrees F. (165° F.), and two hundred degrees F., (200° F.), the cylinder filled without breaking the vacuum. The pressure shall then be raised to and maintained at a minimum of one hundred (100) lbs. per square inch or until the quantity of preservative required to insure the final retention stipulated is injected into the wood, or until the purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than one hundred fifty degrees F., (150° F.), nor more than two hundred degrees F., (200° F.) and shall average at least one hundred eighty degrees F., (180° F.). After the pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than twenty-two (22) inches promptly created and maintained until the wood can be removed from the cylinder free of dripping preservative.

(b) **Empty-Cell Process with Initial Air. (Oil Treatment):** Timber shall be subjected to air pressure of sufficient intensity and duration to provide, under a vacuum, the ejection of surplus preservative, and to insure a retention and proper distribution of the stipulated number of pounds of preservative per cubic foot of wood. The preservative shall be introduced between one hundred sixty-five degrees F., (165° F.), and two hundred degrees F., (200° F.), the cylinder pressure being maintained constant until the cylinder is filled with preservative.

The pressure shall then be raised to and maintained at a minimum of one hundred fifty (150) lbs. per square inch or until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by a quick high vacuum, or until the purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than one hundred fifty degrees F., (150° F.), nor more than two hundred degrees F., (200° F.), and shall average at least one hundred eighty degrees F., (180° F.). After pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum promptly created and maintained until the wood can be removed from the cylinder free of dripping preservative.

(c) **Empty-Cell Process without Initial Air. (Oil Treatment):** The preservative between one hundred sixty-five degrees F., (165° F.) and two hundred degrees F., (200° F.), shall be introduced to the timber until the cylinder is filled. Pressure shall then be raised to and maintained at a minimum of one hundred (100) lbs. per square inch or until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by a quick high vacuum, or until the purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be of not less than one hundred fifty degrees F., (150 F.), nor more than two hundred degrees F., (200° F.), and shall average at least one hundred eighty degrees F. (180° F.). After pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum of not less than twenty-two (22) inches promptly created and maintained for not less than thirty (30) minutes until the quantity of preservative injected is reduced to the required retention and the wood can be removed from the cylinder free of dripping preservative.

(d) **Zinc Chloride Treatment:** The treating solution which shall not have a strength exceeding five per cent (5%), and which shall be no stronger than necessary to obtain the required retention of preservative with the greatest volumetric absorbtion practicable, shall, be thoroughly mixed before use. Air-seasoned timber may be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than twenty (20) lbs. per square inch. After steaming is completed a vacuum of at least twenty-two (22) inches shall be maintained for not less than fifteen (15) minutes or until the wood is as dry and free of air as practicable. If the vacuum is broken while the condensate is being drained from the cylinder a second vacuum as high as the first shall be created. The preservative shall be introduced without breaking the vacuum until the cylinder is filled. The pressure shall then be raised to and maintained at a minimum of one hundred (100) lbs. per square inch until the quantity of preservative required to insure the final retention stipulated is injected into the timber, or until less than five per cent (5%) of the total quantity required has been njected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at one hundred twenty-five (125) or more pounds per square inch.

The temperature of the preservative during the pressure period shall be not less than one hundred forty (140°) degrees F., nor more than two hundred (200°) degrees F and shall average at least one hundred fifty (150°) degrees F. After the pressure is completed, the cylinder shall be emptied speedily of preservative and a vacuum promptly created and maintained until the wood can be removed from the cylinder free of dripping preservative.

70.56. **Pressure Treatments for Douglas Fir:** The following pressure processes shall be used for the oil treatment of Douglas Fir:

Heating with Oil: Air-seasoned or kiln dried Douglas Fir will not be required to be boiled under a vacuum, but it may be desirable to hold the material in a creosote bath maintained at a temperature of one hundred eighty degrees (180°) to one hundred ninety degrees F., (190° F.), for a length of time which, combined with the pressure period, is in the judgment of the operator necessary to secure the specified absorption.

(a) **Full-Cell Process:** Following the heating period, in the case of air-seasoned material, and the seasoning under vacuum period in the case of material artifically seasoned, the cylinder shall be filled with creosote and pressure applied as required to a maximum limit of one hundred seventy-five (175) pounds per square inch and maintained, taking into consideration the quantity of creosote absorbed during the bath, until the specified absorption of creosote has been obtained.

Temperature of the creosote during the pressure period shall be as high as possible, with a minimum limit of one hundred sixty degrees F. (160° F.), and a maximum limit of two hundred degrees F. (200°F.)

After pressure is completed, the cylinder shall be emptied of creosote and a vacuum of at least twenty (20) inches promptly created and maintained for a sufficient period of time to free the material of dripping creosote.

(b) **Empty-Cell Process with Initial Air:** Following the heating period, in the case of air-seasoned material, and the seasoning under vacuum period in the case of material artifically seasoned, the material shall be subjected to air pressure of an intensity and duration which, in the judgment of the operator, is sufficient to accomplish the final retention of creosote specified.

The preservative shall then be introduced, the air pressure being maintained constant, until the cylinder is completely filled.

Creosote shall then be pressed from the measuring tanks into the wood in a quantity sufficient, in the opinion of the operator, to leave the required retention at the completion of the process herein described. Maximum pressure shall in no case exceed two hundred (200) pounds per square inch. The temperature of the creosote during the pressure period shall be as high as possible, within a minimum limit of one hundred sixty degrees F (160° F.), and a maximum limit of two hundred degrees F. (200° F.)

After pressure is completed, the cylinder shall be quickly emptied of creosote and a vacuum of at least twenty (20) inches promptly created and maintained for such period of time as may be required to remove dripping creosote from the material.

SURFACE TREATMENT FOR TIMBER

70.57. **Open Tank Treatments:** Open tank treatment shall consist of a hot bath treatment or a hot and cold bath treatment as may be specified.

70.58. **Equipment:** All tanks used in the open tank process shall be of sufficient size to allow free circulation of the liquid around the largest amount of timber being treated in any operation.

Sufficient liquid shall be maintained in the tanks to completely immerse the timber. When a number of pieces are being treated at each operation, each stick shall be separated from the others on all sides by square or round spaces not less than one-fourth (¼) inch in least dimension. Suitable slings and handling devices shall be provided to make the material transfers necessary during the complete process without disturbing the stacked position of the pieces in the bundle.

For hot bath treatments at least one tank shall be supplied having suitable steam coils or other heating devices to keep the liquid at a uniform temperature throughout the tank of not less than two hundred forty degrees F. (240° F.), during the complete process.

For hot and cold bath treatments at least one hot tank shall be supplied as for the hot bath treatment and one cold tank having the same capacity as the hot tank. The cold tank shall be equipped with suitable cold water coils or water jackets so that the temperature of the liquid at the time of immersion of each batch of timber shall be no higher than the surrounding atmospheric temperature.

70.59. **Preparation of Material:** All timber to be treated shall be free from dirt, grease or other foreign matter which will in any way hinder the free penetration of the preservative. Framing shall be done before treatment. Round timber or timber with wane shall have the rough bark and inner bark removed as specified for wood piling in Division 3, Section 10.

70.60. **Time of Immersion:** The time of immersion as specified herein is for Southern Yellow Pine, Chestnut, Black Gum, Red Oak, Lodgepole Pine, Norway Pine and Pondosa Pine. The specified time of immersion shall be increased sixty-six and two-thirds (66 2/3) per cent for Southern Cypress Douglas Fir, and one hundred (100) per cent for White Oak and Eastern Spruce.

70.61. **Single or Hot Bath Treatment:** The timber shall be completely immersed in preservative in the hot tank, which shall be maintained at a temperature of one hundred ninety degrees F. (190 F.), for seasoned timber and two hundred thirty degrees F. (230° F.), for timber not seasoned. A tolerance of ten (10) degrees in either direction is permissible. For seasoned timber the immersion shall be for a period of not less than fifteen (15) minutes for two-inch timber, with an increase of five minutes in the immersion period for each additional inch in thickness. For timber other than seasoned the immersion period shall be doubled.

70.62. **Ordinary Hot and Cold Treatment:** The timber shall be completely immersed in preservative in the hot tank, which shall be maintained at a temperature of one hundred ninety degrees F., (190° F.), for seasoned timber and two hundred thirty degrees F. (230° F.), for timber not seasoned. A tolerance of ten (10) degrees in either direction is permissible. For seasoned timber the immersion shall be for a period of not less than fifteen (15) minutes for two-inch timber with an increase of five minutes in the immersion period for each additional inch in thickness. For timber other than seasoned the immersion period shall be doubled. At the end of this period the timber shall be removed from the hot tank and immediately immersed in the cold tank. At the time of transfer the preservative in the cold tank shall have a temperature as low as possible but in no case higher than the surrounding air temperature. The timber shall be completely immersed in the cold tank for a period one-half as long as the hot tank.

Successive charges from the hot tank may be placed first in one cold tank and the next in a second cold tank in order to keep the cold tank temperature as low as possible at the time of immersion. Should the Contractor supply a cold tank capable of handling all material and with a cooling system which will keep the temperature at the time of all cold treatments as specified, only one cold tank may be required. Single cold tank equipment shall be subject to the approval of the Engineer.

70.63. **Heavy Hot and Cold Treatment:** The requirements for this treatment are the same as those specified above for the Ordinary Hot and Cold Treatment except that the time of immersion in the cold bath shall be the same as the time of immersion in the hot bath.

70.64. **Brush Treatment:** All timber to be given brush treatment shall be free from atmospheric moisture and in no case shall brush treatment be applied when the surface of the timber is wet. The surfaces to be treated shall be free from dirt, grease, or other foreign matter which will in any way hinder the maximum penetration of the preservative.

The preservative shall be heated in proper receptacles immediately adjacent to the point of application and shall be applied within the temperature range of one hundred seventy degrees (170° F.), to one hundred ninety degrees (190°F.), for seasoned wood and two hundred twenty degrees (220° F.), to two hundred forty degrees F., (240° F.), for unseasoned wood.

A minimum of two coats shall be applied to all surfaces to be treated except cut ends, joints and mortises which shall be given three coats. Each coat shall be allowed to penetrate before applying the next coat. All checks, bolt holes and cracks shall be run full of the preservative oil and an extra heavy treatment shall be given to knotty spots.

70.65. **Spray Treatment:** The condition of the timber prior to spray treatment shall conform to the requirements specified for brush treatment.

The temperature of the preservative shall be maintained at two hundred forty degrees F. (240° F.) The shortest length of hose practicable shall be used to prevent undue chilling between the spray tank and nozzle. Preservative shall be renewed frequently in the spray tank to prevent chilling. The spray shall be applied with a good pressure and only fine enough to prevent waste, until the preservative begins to run. Equipment employing air pressure which has a coolingeffect on the hot preservative shall not be used.

Two liberal applications shall be made allowing sufficient time for the absorption of the first application before the second is made.

70.66. **Painting:** Untreated or salt treated wood rails and rail posts shall be painted with three (3) coats of white paint conforming to the requirements of Paragraph 69.49d.

Parts of the structure, other than rails and rail posts, which are to be painted shall be designated on the plans or in the supplemental specifications.

Metal parts, except hardware, shall be given one coat of shop paint and, after erection, two coats of field paint.

70.67. **Basis of Payment:** Payment for timber structures shall include the furnishing of materials, preservative treatment, equipment, tools and labor necessary for the erection and painting of the work in a satisfactory manner.

Lumber and timber shall be paid for at the contract price per thousand feet board measure (M. B. M.) for material remaining in the finished structure, which payment shall include the cost of all hardware. Computations of the amount of lumber and timber in the structure shall be based on nominal sizes and the shortest commercial length which could be used. No other allowance for waste will be made.

Metal parts, other than hardware, shall be paid for at the contract price per pound, the weight being computed in the same manner as specified for Steel Structures, Section 69.

Payment will be made under
Item No. 74, Bridge Timber (untreated) per M. B. M.
Item No. 75, Bridge Timber (treated) per M. B. M.

SECTION 71

PILING

(a) BEARING PILES

71.01. **Description:** Bearing piles shall consist of round or square piling of the kind and dimensions specified, placed at the locations and to the elevations indicated on the plans or as directed by the Engineer, and in conformity with the requirements and provisions of these Specifications.

MATERIAL

TIMBER PILES

71.02. **General:** Timber piles which will be below water level at all times, may be of any species of wood which will satisfactorily withstand driving.

In untreated piling for use in exposed work, the diameter of the heartwood shall be not less than (eight-tenths (8/10) of the required diameter of the pile.

71.03. **Quality:** All wood piling shall be cut from sound and solid trees, preferably during the winter season. They shall contain no unsound knots. Sound knots will be permitted provided the diameter of the knot does not exceed four (4) inches or one-third (1/3) of the diameter of the stick at the point where it occurs. Any defect or combination of defects which will impair the strength of the pile more than the maximum allowable knot shall not be permitted. The butts shall be sawed square and the tips shall be sawed square or tampered to a point not less than four (4) inches in diameter as directed by the Engineer.

Unless otherwise specified all piles shall be peeled by removing all of the rough bark and at least eighty (80%) of the inner bark. No strip of inner bark remaining on the stick shall be over three-quarters (¾) inch wide or over eight (8) inches long, and there shall be at least one (1) inch of clean wood surface between any two such strips. Not less than eighty (80%) of the surface on any circumference shall be clean wood.

Piles shall be cut above the ground swell and shall taper from butt to tip. A line drawn from the center of the tip to the center of the butt shall not fall outside of the center of the pile at any point more than one (1%) of the length of the pile. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed four (4%) of the length of the bend or two and one-half (2½) inches. All knots shall be trimmed close to the body of the pile.

71.04. **Dimension:** Round piles shall have a minimum diameter at the tip, measured under the bark, as follows:

Length of Pile	Tip Diameter
Less than 40 feet	8″
40 to 60 feet	7″
Over 60 feet	6″

The minimum diameter of piles at a section four feet from the butt, measured under the bark, shall be as follows:

Length of Pile		Diameter
	Sou. Yellow Pine—Sou. Cypress	All other species
20 feet and under	11″	11″
20 to 30 feet	12″	12″
30 to 40 feet	12″	13″
Over 40 feet	13″	14″

The diameter of the piles at the butt shall not exceed twenty (20) inches.

Square piles shall have the dimensions shown on the plans.

Cypress piles for untreated timber trestles shall be of red or black cypress and shall have heartwood with a minimum diameter at a section four feet from the butt of nine (9) inches for piles with a length of thirty feet and under and ten (10) inches for piles over thirty feet in length. In determining the heartwood diameter it shall be assumed that the taper is in the same ratio as the taper of the outside of the pile.

71.05. Timber Preservatives shall conform to the requirements specified under Timber Structures Section 70, Pamphlet "G."

71.06. Materials for concrete piles shall conform to the material requirements specified in Section 67 "Concrete Structures" and Section 68 "Reinforcement in Structures" for the several items which constitute the structure.

CONSTRUCTION METHODS

71.07. **Limitation of Use:** Except for trestle work, timber piles shall be used only below permanent ground water level. Untreated timber biles shall not be used in water which is infested by marine borers.

In general, the penetration for any pile shall be not less than 10 feet in hard material and not less than one-third the length of the pile nor less than 20 feet in soft material.

For foundation work, no piling shall be used to penetrate a very soft upper stratum overlying a hard stratum unless the piles penetrate the hard material a sufficient distance to rigidly fix the ends.

71.08. **Preparation for Driving:** Piles shall not be driven until after the excavation is complete. Any material forced up between the piles shall be removed to correct elevation before masonry for the foundation is placed.

71.09. **Caps:** The heads of all concrete piles, and the heads of timber piles when the nature of the driving is such as to unduly injure them, shall be protected by caps of approved design, preferably having a rope or other suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block. When the area of the head of any timber pile is greater than that of the face of the hammer, a suitable cap shall be provided to distribute the blow of the hammer throughout the cross section of the pile and thus avoid, as far as possible, the tendency to split of shatter the pile.

71.10. **Collars:** Collars or bands to protect timber piles against splitting and brooming shall be provided where necessary.

71.11. **Pointing:** Timber piles shall be pointed where soil conditions require it. When necessary, the piles shall be shod with metal shoes of a design satisfactory to the Engineer, the points of the piles being carefully shaped to secure an even and uniform bearing on the shoes.

71.12. **Splicing Timber Piles:** Full length piles shall always be used where practicable but if splices cannot be avoided an approved method of splicing shall be used. Piles shall not be spliced except by permission of the Engineer.

71.13. **Method of Driving:** Piles shall be driven with a gravity hammer, steam hammer, or a combination of water jets and hammer. Concrete piles preferably shall be driven by means of a combination of hammer and jets.

EQUIPMENT FOR DRIVING

71.14. **Hammers for Timber Piles:** Gravity hammers for driving timber piles shall weigh not less than two thousand (2000) pounds and the fall shall be so regulated as to avoid injury to the pile and in no case shall exceed twenty (20) feet.

71.15. **Hammers for Concrete Piles:** Concrete piles preferably shall be driven with steam or gravity hammers. Steam hammers for this purpose shall develop an energy per blow at each full stroke of the piston of not less than thirty-five hundred (3500) foot pounds per cubic yard of concrete in the pile being driven. The total energy developed by the hammer shall be not less than twelve thousand (12000) foot pounds per blow.

Gravity hammers, when used, shall have a weight not less than that of the pile and the maximum drop shall not exceed eight (8) feet.

71.16. **Leads:** Pile driver leads shall be constructed in such manner as to afford freedom of movement to the hammer and they shall be held in position by guys or stiff braces to insure support to the pile during driving. Except where piles are driven through water, the leads preferably shall be of sufficient length so that the use of a follower will not be necessary.

71.17. **Followers:** The driving of piling with followers shall be avoided if practicably and shall be done only under written permission of the Engineer. When followers are used, one pile from every group of ten shall be a long pile driven without a follower, and shall be used as a test pile to determine the average bearing power of the group.

71.18. **Water Jets:** When water jets are used, the number of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the fil,. The plant shall have sufficient capacity to deliver at all times at least one hundred (100) pounds per sq. in. pressure at two ¾ in. jet nozzles. Before the desired penetration is reached the jets shall be withdrawn and the piles shall be driven with the hammer to secure the final penetration.

71.19. **Allowable Variation in Driving:** Piles shall be driven with a variation of not more than one-quarter (¼) inch per foot from the vertical or from the batter line indicated.

DETERMINATION OF BEARING VALUES

71.20. **Loading Tests:** When required, the size and number of piles shall be determined by actual loading tests. In general, these tests shall consist of the application of a test load placed upon a suitable platform supported by the pile, together with suitable apparatus for accurately determining the superimposed weight and the settlement of the pile under each increment of load. The safe allowable load shall be considered as fifty (50) per cent of that load which, after forty-eight (48) hours application, causes a permanent settlement, measured at the top of the pile, of not more than one-fourth (¼) inch. At least one pile for each group of one hundred piles shall be thus tested.

71.21. **Timber Piles:** In the absence of loading tests, the safe bearing values for timber piles shall be determined by the following formulas:

$$P = \frac{2\,WH}{S + 1.0} \text{ for gravity hammers}$$

$$P = \frac{2\,WH}{S + 0.1} \text{ for single-acting steam hammers}$$

$$P = \frac{2H(W + Ap)}{S + 0.1} \text{ for double-acting steam hammers}$$

Where P = Safe bearing power in pounds.
W = Weight, in poundsm of striking parts of hammer.
H = Height of fall in feet.
A = Area of piston in square inches.
p = Steam pressure in pounds per square inch at the hammer.
S = The average penetration in inches per blow for the last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for steam hammers.

The above formulas are applicable only when:

(a) The hammer has a free fall.
(b) The head of the pile is free from broomed or crushed wood fibre.

(c) The penetration is at a reasonably quick and uniform rate.
(d) There is no appreciable bounce after the blow. Twice the height of the bounce shall de deducted from "H" to determine its true value in the formula.

The bearing powers of timber piles, as determined by the foregoing formulas, shall be considered effective only when they are less than the crushing strengths of the piles. In general, piles shall be required to develop in bearing capacity of not less than fifteen (15) tons nor more than twenty-five (25) tons. However, the character of the soil penetrated, conditions of driving, distribution, sizes and lengths of the piles involved, and the computed load per pile shall be given due consideration in determining the reliability of driven piles.

In case water jets are used in connection with the driving, the bearing power shall be determined by the above formulas from the results of driving after the jets have been withdrawn, or a load test may be applied.

71.22. **Concrete Piles:** The bearing values for concrete piles shall be determined by means of the loading tests above specified. The formulas specified above for timber piling may be used as a rough approximation for precast concrete piles and they may also be applied to the driven core for cast-in-places piles.

71.23. **Test Piles:** When required, the Contractor shall drive test piles of a length and at the location designated by the Engineer. These piles shall be of greater length than the length assumed in the design in order to provide for any variation in soil conditions.

71.24. **Order Lists for Piling:** The Engineer shall furnish the Contractor with an itemized list showing the number and length of all piles and the Contractor shall furnish piles in accordance with such itemized list.

(b) **TIMBER PILES**

71.25. **Storage and Handling:** The method of storing and handling shall be such as to avoid injury to the piles. Special care shall be taken to avoid breaking the surface of treated piles and cantdogs, hooks or pikepoles shall not be used. Cuts or breaks in the surface of treated piling shall be given three brush coast of hot creosote oil of approved quality and hot creosote oil shall be poured into all bolt holes.

71.26. **Elevation:** The tops of all piling shall be sawed to a true plane as shown on the plans and at the elevation fixed by the Engineer. Piles which support timber caps or grillage work shall be sawed to the exact plane of the superimposed structure and shall exactly fit it. Broken, split of misplaced piles shall be drawn and properly replaced. Piles driven below the cut-off grade fixed by the Engineer shall be withdrawn and replaced by new and, if necessary, longer piles at the expense of the Contractor. All piles raised during the process of driving adjacent piles shall be driven down again if required by the Engineer.

(c) **CONCRETE PILES**

71.27. **Manufacture of Precast Concrete Piles:**

71.28. **Size and Shape:** Precast concrete piles shall be of approved size and shape. If a square section is employed, the corners shall be chamfered at least one inch. Piles preferably shall be cast with a driving point and for hard driving preferably shall be shod with a metal shoe of approved pattern. Piling may be either of uniform section or tapered. In general tapered piling shall not be used for trestle construction except for that portion of the pile which lies below the ground line; nor shall tapered piles be used in any location where the piles are to act as columns. In general, concrete piles shall have a cross sectional area, measured above the taper, of not less than one hundred and forty (140) square inches and when they are to be used in salt water they shall have a cross sectional area of not less than two hundred and twenty (220) square inches.

71.29. **Class of Concrete:** Class "D" concrete shall be used for precast concrete piles.

71.30. **Reinforcement:** Reinforcement for precast concrete piles, shall consist of longitudinal bars in combination with lateral reinforcement in the form of hoops or spirals. The longitudinal reinforcement shall be not less than one (1) per cent and preferably not less than one and one-half ($1\frac{1}{2}$) percent of the total cross-section of the pile. The reinforcement shall be placed at a clear distance from the face of the pile of not less than two (2) inches and when the piles are for use in salt water or alkali soils this clear distance shall be not less than three (3) inches. The driving point and also the top of the pile shall be protected against impact by means of special spiral winding or bands designed for this purpose. The reinforcing system preferably shall be of the unit type, rigidly wired or fastened at all inter-sections and held to true position in the forms by means of concrete blocks or other suitable device. When piles exceed fifty-five (55) feet in length, additional longitudinal reinforcement shall be added throughout the central one-third (1/3) of the length. Piling under retaining walls, arch footings, abutments, etc., shall be designed to withstand the lateral stresses induced.

71.31. **Form Work:** Forms for precast concrete piles shall conform to the general requirements for concrete form work as provided in Paragraph 67.36 under "Concrete Masonry". Forms shall be accessible for tamping and consolidation of the concrete. Under good weather curing conditions side forms may be removed at any time not less than twenty-four (24) hours subsequent to placing concrete, but the entire pile shall remain supported for at least seven days and shall not be subjected to any handling stress until the concrete has set for at least twenty-one (21) days and for a longer period in cold weather, additional time to be determined by the Engineer.

71.32. **Casting:** Piling may be cast either in a vertical or horizontal position. Special care shall be exercised to puddle and tamp the concrete around the reinforcement and to avoid the formation of stone pockets.

During the placing of concrete the forms shall be vibrated by taping with a hammer or wooden maul. Concrete shall be placed continuously in each pile and shall be carefully spaded, puddled and tamped, special care being exercised to avoid horizontal or diagonal cleavage planes, and to see that the reinforcement is properly embedded in the concrete.

71.33. **Finish:** As soon as the forms are removed, concrete piles shall be carefully gone over and pointed with 1:2 morter, filling up all cavities or irregularities. Trestle piling exposed to view shall be finished above the ground line in accordance with the provisions governing the finishing of concrete columns. Foundation piling, that portion of trestle piling which will be below the ground surface, and piles for use in sea water or alkali soils shall not be finished except by pointing as above set forth.

71.34. **Curing:** Concrete piles shall be cured in accordance with the general provisions governing the curing of concrete Paragraph 67.33. As soon as the piles have set sufficiently to permit, they shall be removed from the forms and piled in a curing pile separated from each other by wood spacing blocks. No pile shall be driven until it has set for at least thirty (30) days and in cold weather for a longer period as determined by the Engineer. Concrete piles for use in sea water or alkali soils shall be cured for not less than sixty (60) days before being used.

71.35. **Storage and Handling of Precast Concrete Piles:** For precast concrete piles, the method of storing and handling shall be such as to eliminate the danger of fracture, by impact or undue bending stresses, in curing or transporting the piles from the molds and into the leads. In general, concrete piles shall be lifted by means of suitable bridle or sling attached to the pile at points not over twenty feet apart. In no case shall the method of handling be such as to induce stresses in the reinforcement in excess of twelve thousand (12,000) pounds per square inch, allowing one hundred percent of the calculated load for impact and shock effects.

In handling piles for use in sea water or alkali soils special care shall be exercised to avoid injury to the surface of the pile.

(d) MANUFACTURE OF CAST-IN-PLACE CONCRETE PILES

71.36. **Description:** Cast-in-place concrete piles shall be cast in strong metal shells which shall remain permanently in place.

71.37. **Metal Shells:** The metal shall be of a sufficient thickness and reinforced to such an extent that it will hold its original form and show no signs of distortion after the core has been withdrawn. The design of the shell shall be submitted to and approved by the Engineer before any driving is done.

71.38. **Inspection of Shells:** After the shell has been driven and the core withdrawn, the shell shall be inspected and approved before any concrete is placed. No payment will be made for any shell which has been improperly driven, is broken, or otherwise defective and, if necessary, any such shell shall be removed and replaced.

71.39. **Class of Concrete:** Class "D" concrete shall be used for cast-in-place concrete piles.

71.40. **Reinforcement:** Reinforcement for cast-in-place piles shall be of the unit type, rigidly fastened together and lowered into the shell before concrete is placed. No loose bars will be permitted. The reinforcement shall be secured in such a manner as to insure its proper location in the finished pile.

71.41. **Placing Concrete:** No concrete shall be placed until all driving within a radius of fifteen (15) feet has been completed, or until all the shells for any one bent have been completely driven. If this cannot be done, all driving within the above limits shall be discontinued until the concrete in the last pile cast has set at least seven (7) days.

Concrete shall be placed continuously in each pile, care being used to fill every part of the shell and to work concrete around the reinforcement without displacing it. No concrete shall be placed in shells containing an accumulation of water.

71.42. **Extensions or "Build Ups".** Extensions, splices or "Build Ups" on concrete piles shall be avoided but when necessary they shall be made as follows:

After the driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcing steel exposed for a length of forty diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary form work shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of the same quality as that used originally in the pile. Just prior to placing concrete the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement, retempered mortar or other suitable bonding Naterial. The forms shall remain in place not less than seven (7) days and shall then be carefully removed and the entire exposed surface of the pile finished as above specified.

MEASUREMENT AND PAYMENT

71.43. **Payment for Timber Piles:** Payment for timber piles shall include the cost of furnishing all materials, including collars, equipment, labor and other items necessary for driving and cutting off such piles as are required. It shall also include the placing, but not furnishing, of all permanent bracing and caps which may be required and the furnishing and placing of any temporary bracing necessary to hold the piles in alignment, Metal shoes, when required, shall be paid for as a separate item or as extra work.

The number of linear feet paid for shall be the actual number of feet remaining in the finished structure. In addition to this, payments based on the actual cost of materials, shall be allowed for that portion of any cutoff in excess of two (2) feet. No payment shall be made for two (2) feet of any cutoff. Cut-off lengths shall become the property of the state. No allowance will be made for false-work piling.

71.44. **Payment for Concrete Piles:**

(1) **Cast-in-Place Piles:** Payment for cast-in-place concrete piles shall include the cost of furnishing all materials, equipment, labor and other items necessary for driving and casting the piles. The number of linear feet paid for shall be the actual number of linear feet remaining in the finished structure.

(2) **Precast Piles:** Payment for precast concrete piles shall include the cost of furnishing all materials, equipment, labor and other items necessary for casting, curing and driving the piles as ordered. Payment for precast piles will be made on the basis of the actual number of linear feet ordered by the Engineer from which a deduction of one-half the contract price per linear foot will be made for the length of piling cut off. In case "build ups" are necessary the built up length will be paid for at the contract price per linear foot for piles in place but no allowance will be made for "build ups" which are made necessary by damage to the piles during driving.

71.45. **Payment for Piles Ordered and Not Driven:** Piles ordered and not driven shall be paid for on the basis of cost plus five (5) per cent and shall thereupon become the property of the state.

71.46. **Payment for Test Piles:** Test piles ordered by the Engineer shall be paid for as follows:

If the test indicates that piles should be used and if they are used, the test piles will be paid for as provided hereinabove for other piles. If, however, piling is not used in the structure, the test piles will be paid for as provided for extra work, due consideration being given to the cost of bringing the driver to the site and removing it from the work.

71.47. **Payment for Loading Tests:** Payment for loading tests shall include the cost of all materials, equipment and labor incidental to constructing the loading platform, procuring and placing the loading material, and removing and disposing of the platform and material to the satisfaction of the Engineer. Payment shall be made on the basis of the contract price for pile loading tests or, in the absence of such a price, shall be made on the basis of extra work.

Payment will be made under

- Item No. 76, Timber Piling Treated (per linear foot).
- Item No. 77, Timber Piling Untreated (per linear foot).
- Item No. 78, Concrete Cast-in-Place Piles (per linear foot).
- Item No. 79, Concrete Precast Piles (per linear foot).
- Item No. 80, Loading Test (each).

SECTION 72

CONCRETE CULVERTS-RETAINING WALLS AND END WALLS

72.01. **Description:** All concrete culverts or structures twenty (20) feet or less (measured along the center line of road), all pipe culverts, end-walls, and retaining walls, shall be built as indicated on the plans, conforming to line, grade, dimensions, and design shown, and in accordance with the Specifications for "Concrete Structures" and "Pipe" of the several varieties, which are to constitute the complete structures.

MATERIALS

72.02. **Materials:** Materials used shall be those prescribed for the several items which constitute the structure.

CONSTRUCTION METHODS

72.03. **General:** The construction methods used shall be those prescribed for the several items which are to constitute the structure.

72.04. **Foundations:** All foundations shall be prepared as hereinbefore specified under "Excavation for Bridges, Culverts, and Retaining Walls" and they shall be inspected and approved by the Engineer previous to placing any concrete. All foundations shall be poured in the "Dry" except as provided in the Special Provisions or unless otherwise permitted by the Engineer in writing.

When footings can be placed in the dry without the use of cribs or cofferdams, backforms may be omitted at the discretion of the Engineer and the entire excavation filled with concrete to the required elevation of the top of the footing.

Whenever the natural foundation material is insufficient to safely support the structure, or whenever excessive erosion during the flood periods is to be expected, the Engineer may direct that piles be driven under the culvert. In this case the piling shall be proportioned to carry the entire load in accordance with the provisions and formulas governing the use of piling as set forth in these Specifications.

Timber grillage work may also be used to distribute the hearing area for culverts in very soft natural ground provided the location is such that no erosive action need be feared. Timber grillage of this character must be placed so as to lie below the lowest natural ground water level and shall be built as approved by the Engineer.

72.05. **Construction Joints:** Concrete in substructures shall be placed in such manner that all construction joints will be truly horizontal and, if possible, in such location as not to be exposed to view in the finished structure. Special care shall be taken to avoid construction joints through parallel wingwalls or any large surface which are to be treated architecturally.

72.06. **Aprons and Curtain Walls:** Aprons or curtain walls shall, in general, be carried down at both ends to the depth shown on the plans, but may be ordered by the Engineer to such additional depth as may appear necessary to prevent undermining.

If deemed necessary, in order to prevent scour, the Engineer may direct that the space between the wings be paved. In this event, the apron walls will extend in a straight line between the ends of wings, or at such location as may afford the best protection.

72.07. **Drainage:** Adequate drainage of fills around culverts shall be insured by the construction of weep holes, French drains, or underdrains as may be indicated on the plans or directed by the Engineer.

72.08. **Class of Concrete:** Unless otherwise specified, all reinforced concrete culverts shall be of Class "A" concrete. Headwalls shall be built of the class of concrete indicated on the plans.

72.09. **Method of Placing Concrete:** Each wing wall above top of footing shall be constructed as a monolith.

When placing the bottom slab, suitable provision shall be made for bonding the sidewalls to the culvert base, preferably by means of longitudinal keys so constructed as to prevent, as far as possible, the percolation of water through the construction joint.

Before concrete is placed in the sidewalls, the bottom slab shall be thoroughly cleaned of all shavings, sticks, sawdust, or other extraneous material and the surface carefully chipped and roughened in order to insure a good bond as required by these Specifications.

72.10. **Pipe Culverts:** Pipe culverts under the roadbed shall be so placed that the minimum distance from finished grade of roadway to the top of pipe shall be as provided on the plans or ordered by the Engineer.

Construction methods applying to pipe culverts shall be as set forth under the several items covering the different kinds of pipe specified.

72.11. **Headwalls:** The ends of all pipe culverts shall be protected by concrete or masonry end walls unless otherwise ordered by the Engineer.

72.12. **Method of Measurement:** The quantities of the various items which constitute the completed and accepted structures will be measured for payment according to the plans and specifications for the several items. Only accepted work will be included and the dimensions used will be the neat dimensions shown on the plans or ordered in writing.

72.13. **Basis of Payment:** The measured quantities as provided above, will be paid for at the contract unit prices for the several items which prices shall be full compensation for furnishing, hauling and placing all material, all labor, equipment, tools and necessary incidentals. Such payment shall constitute full payment for the completed structure ready for use. Whenever the construction of the new structures involves the removal or demolition of an existing structure, such removal or demolition shall not be paid for except as "Excavation for Structures."

SECTION 73

RUBBLE MASONRY

(a) CEMENT RUBBLE

73.01. **Description:** This item shall be composed of approved stones laid in mortar beds and shall be constructed in accordance with these Specifications and in conformity with the plans or as directed by the Engineer.

MATERIALS

73.02. **Stone:** One-man and derrick stone used in rubble or cyclopean concrete shall consist of tough, sound and durable rock. The stone shall be free from coatings, drys, seams, or flaws of any character. In general, the percentage of wear shall be not greater than six (6) per cent as determined by the "Abrasion Test for Broken Stone" provided in Standard Methods of Sampling and Testing of the American Association of State Highway Officials (A. S. T. M. Standard Method, Serial Designation D2-08, slightly modified.)

Preferably, stone shall be angular in shape and shall have a rough surface such as will thoroughly bond with the surrounding mortar.

Mortar: Mortar shall be of Portland cement and sand mixed in the proportions of one (1) part of cement to three (3) parts of sand. At the option of the contractor, hydrated lime in amount not to exceed ten (10) per cent of the amount of cement used, may be added to the mortar. Materials for this mortar shall meet the requirements specified under Section 67 Concrete Structures.

CONSTRUCTION METHODS

73.03. **Construction Methods:** The manner of laying shall conform to the following requirements. The bottom or foundation courses shall be composed of selected large, flat stones and all courses shall be laid with bearing beds parallel to the natural bed of the material.

All hammering or tooling of the stone must be done before the stone is laid in the wall and no further dressing or tooling will be permitted after the stone is placed.

All stone shall be thoroughly saturated with water before being laid.

The mortar joints shall be full and the stone carefully settled in the mortar. No spalls will be allowed in the beds.

If during the course of construction the bond is broken between any stone and the surrounding mortar, the stone shall be removed and the mortar entirely cut out and replaced when the stone is relaid.

No stone less than six (6) inches in thickness and twelve (12) inches in width shall be used, except for filling the interior of the wall.

Stones shall decrease in thickness from bottom to top.

Stones must be carefully bonded and leveled and so selected that at least twenty (20) per cent of the stones are headers. Such headers shall be evenly distributed throughout the surface of the wall and preferably arranged to interlock. On walls 2′—0″ or less in thickness, headers shall extend clear through.

Selected stone, roughly squared and pitched to line shall be used for angles and ends of walls. If required all corners or angles for exterior surfaces shall be finished with a chisel draft one and one-half (1½) inches in width.

The minimum thickness of mortar between any two (2) stones shall be one-half (½) inch.

Vertical joints on the faces of walls shall be broken at least six (6) inches. In no case shall a vertical joint occur directly above or below a header.

The contractor shall construct weep holes where called for on the plans. No extra compensation will be rendered for the construction of weep holes, the cost of all labor material incident to the same being presumably included in the pr ce bid for masonry.

Unless otherwise specified upon the plans, Copings, Bridge Seats, and Back-walls shall be constructed of Class "A" concrete, Section 67, paragraph 67.26, and shall conform to the requirements for concrete structures Section 67.

Concrete Copings shall be made in sections extending the full length of the wall, not less than eight (8) inches in thickness, and from five (5) to ten (10) feet long. The sections may be cast in place or pre-cast and set in place in full mortar beds.

73.04. (b) **DRY RUBBLE**

73.05. **Description:** This item shall be composed of approved stones laid without mortar, and shall be constructed in accordance with these specifications and in conformity with the plans or as directed by the Engineer.

73.06. **Stone:** Stone for this class of work may be of any material which is sound, durable, free from segregations, rifts or seams or any other defect operating to destroy its natural resistance to the weather.

CONSTRUCTION METHODS

73.07. **Construction of Methods:** All bottom or foundation courses shall be composed of selected, large, flat stone and all courses shall be laid with bearing beds parallel to the natural bed of the material. All hammering or tooling of the stone must be done before the stone is laid in the wall. All stone shall be carefully fitted in such manner as to reduce the maximum width of any open joint to not more than one (1) inch. No stone less than six (6) inches in thickness and twelve (12) inches in width shall be used except for filling the interior of the wall.

Stone shall decrease in thickness from bottom to top, and shall be carefully bonded and leveled and so selected that at least twenty (20) per cent of the stone are headers. Headers shall be evenly distributed throughout the surface of the wall and preferably arranged to interlock. Selected stone roughly squared and pitched to line shall be used for angles, or for the ends of walls. Vertical joints on all wall faces shall be broken at least four (4) inches.

73.08. **Basis of Payment:** These items will be paid for at the contract unit price per cubic yard for "Cement Rubble Masonry" or "Dry Rubble Masonry," as the case may be, complete in place, which price shall be full compensation for all material equipment, tools, labor and incidentals necessary to complete the item in accordance with the plans and these specifications. In determining the volume of masonry structures the plan dimensions will be used and no allowance will be made for work done outside the neat lines indicated on the drawings.

Payment will be made under
Item No. 81, Cement Rubble Masonry (cubic yard).
Item No. 82, Dry Rubble Masonry (cubic yard).

SECTION 74

BRICK MASONRY

74.01. **Description:** Brick masonry shall consist of brick laid in cement mortar and shall include such construction with building brick or ornamental brick as may be specified. Brick pavements are not included under this designation.

MATERIALS.

74.02. **Brick:** Brick for masonry construction shall conform to the requirements of the Standard Specifications for Building Brick, Serial Designation C21-20, of the American Society for Testing Materials, with subsequent amendments and additions thereto adopted by the Society. Unless otherwise specified, all bricks shall conform to the class requirements for "Hard Brick".

The bricks shall have a fine grained, uniform and dense structure, free from lumps of lime, laminations, cracks, checks, soluble salts or other defects which may in any way impair their strength, durability, appearance or usefulness for the purpose intended. Bricks shall emit a clear, metallic ring when struck with a hammer.

74.03. **Mortar:** Mortar shall be of Portland Cement and sand, mixed in the proportions of one part of cement to three parts of sand. At the option of the contractor hydrated lime in amount not to exceed 10 per cent of the amount of cement used, may be added to the mortar. Materials for this mortar shall meet the requirements specified in Section 67 for "Concrete Structures."

CONSTRUCTION METHODS

74.04. **Laying:** The brick shall be laid using the "shove-joint" method, so as to thoroughly bond them into the mortar. All brick shall be saturated with water before being laid, and headers and stretchers shall be so arranged as to thoroughly bond the mass. Unless otherwise specified brick work shall be of alternate headers and stretchers with alternate courses breaking joints, (Flemish Bond). Joints shall be finished properly as the work progresses, and shall be not less than one-quarter (¼) of an inch nor more than one-half (½) of an inch in thickness. No spalls nor bats shall be used, except shaping around irregular openings or when unavoidable at corners. None but expert brick layers shall be employed on the work.

74.05. **Basis of Payment:** This item will be paid for at the contract unit price either by the cubic yard of "Brick Masonry", or by the thousand brick laid, (The method of payment will be set forth in the proposal), complete in place, which price shall be full compensation for all equipment, tools, labor, materials, scaffoling and other things necessary to complete the item in accordance with the plans and these specifications. Filling materials for the interior of the wall, when not of brick, and concrete or mortar copings, shall be paid for on the basis of the number of cubic yards actually placed.

Payment will be made under
Item No. 83 (a)—Brick Masonry (per cubic yard).
Item No. 83 (b)—Brick Masonry (per thousand brick laid).

PAMPHLET "I"

GEORGIA STATE HIGHWAY DEPARTMENT

STANDARD SPECIFICATIONS

1928

DIVISION III

DESIGN

SECTION 87

GENERAL FEATURES

TYPES AND CLASSIFICATION OF BRIDGES

87.01. (a) **Types of Bridges:**

The different types of bridges may be used within the following limits, due consideration being given to transportation and erection conditions in selecting the type to be used.

Steel Structures:

Rolled beams for spans up to	45 feet
Plate girders for spans	30 to 125 feet
Riveted half-through trusses for spans	45 to 100 feet
Riveted trusses for spans above	90 feet
Pin-connected trusses for spans above	150 feet

Concrete and Stone Masonry Structures:

Slab spans, up to	24 feet
Simple girder spans	18 to 60 feet
Arches	All span lengths

87.02. (b) **Classification of Bridges:**
The classification of bridges with reference to traffic shall be as follows:

ClassAA: Bridges for specially heavy traffic units in locations where the passage of such loads is frequent.

Class A: Bridges for normally heavy traffic units and the occasional passage of specially heavy loads.

Class B: Bridges for light traffic units and the occasional passage of normally heavy loads. Class B bridges shall be considered as temporary or semi-temporary structures.

Class D: Bridges for electric railway traffic in addition to highway traffic. The latter may correspond to any one of the classes described above.

87.03. **Clearance:** Bridge construction for highway traffic only shall not encroach on the space indicated by the clearance diagram shown in Figure 1. On structures carrying electric railways the clearance shall be increased to meet the requirements of the case, but the minimum distance from center of track to structure shall be six (6) feet.

87.04. **Width of Roadway:** The minimum width of roadway shall be nine (9) feet for each line of traffic with a minimum width of twelve (12) feet for one line of traffic.

In structures on curves and carrying electric railways the clearance shall be increased where necessary to provide for curvature and super-elevation of rail.

87.05. **Curbs:** The projection of the curb, measured from that portion of the rail nearest the roadway, shall be not less than six (6) inches and preferably shall be not less than nine (9) inches. The curb height shall be not less than eight (8) inches above the adjacent finished roadway surface.

Concrete curbs shall be designed to resist a lateral force of not less than five hundred (500) pounds per linear foot of curb, applied at the top of the curb.

87.06. **Railings:** Substantial railings shall be provided along each side of the bridge for the protection of traffic. Preferably, the top of railing shall be not less than three (3) feet above the finished surface of the roadway adjacent to the curb and, when on a sidewalk, shall be not less than three (3) feet above the sidewalk floor.

In general, railings shall be of two classes, as follows:

1. Railings suitable for use on country bridges which are not subject to general pedestrian traffic.

2. Railings for the protection of pedestrians on bridges in cities and villages.

(a) **Metal Railings:** Metal railings shall be designed to resist a horizontal force of not less than one hundred (100) pounds per linear foot, applied at the top of the rail, and a vertical force of not less than one hundred (100) pounds per linear foot.

Metal railings of the first class may consist of not less than two lines of horizontal rails of approved section.

Metal railings of the second class shall consist of an upper and a lower horizontal rail connected by a suitable web. The clear distance between the top of curb or sidewalk and the lower rail shall not exceed six (6) inches.

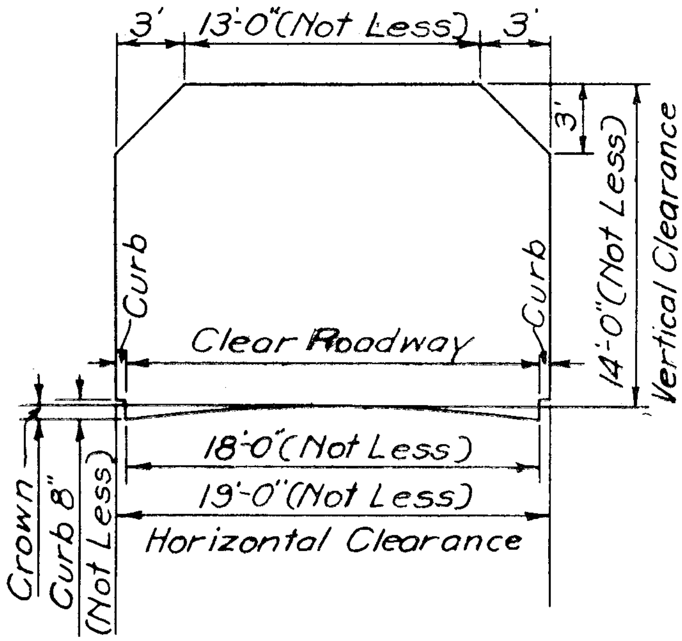
In each connection of railing to the posts, truss members, etc., there shall be not less than two rivets or bolts each. Ample provision shall be made for movement due to temperature.

(b) **Concrete Railings:** Concrete railings shall be designated to resist a horizontal force of not less than one hundred and fifty (150) pounds per linear foot, applied at the top of the rail, and a vertical force of one hundred (100) pounds per linear foot.

Openings in concrete railings of the second class shall be proportioned with due regard to the safety of persons using the structure.

Provisions shall be made for the expansion and contraction of concrete railings at intervals consistent with the design.

87.07. **Drainage:** The transverse drainage of roadways shall be secured by means of a suitable crown in the roadway surface. Longitudinal drainage shall be secured by means of scuppers or drains of ample size, constructed in the gutters or curbs at suitable intervals. The details of floor drains shall be such as to prevent the discharge of drainage water against any portion of the structure. Overhanging details in concrete and timber floors preferably shall be provided with drip beads.



TWO WAY HIGHWAY TRAFFIC
Fig. I

SECTION 88.

LOADS

88.01. 1. **Loads:** Structures shall be proportioned for the following loads and forces:

(a) Dead Load.
(b) Live Load.
(c) Impact or dynamic effect of the live load.
(d) Lateral forces.
(e) Other forces, when these exist, as follows:
Longitudinal force; centrifugal force; force of stream current and drift; earth pressure; and the thermal forces.

Members shall be proportioned for that combination of loads and forces producing the maximum total stress, except as otherwise provided.

Upon the stress sheets for steel structures a diagram of the assumed live loads shall be shown and the stresses due to the various loads shall be shown separately. For structures of material other than steel, the assumed live loads shall be shown upon stress sheets or other drawings and, when required, the stresses due to the various loads shall be shown.

88.02. **Dead Load:** The dead load shall consist of the weight of the structure complete, including the weight of the roadway floor together with car tracks, pipes, conduits, cables, or other public utility services.

In the case of structures having concrete slab floors, an adequate allowance shall be made in the design dead load to provide for the weight of a suitable wearing surface. This allowance will depend upon the type of wearing surface contemplated; it shall be in addition to the weight of any monolithically placed concrete wearing surface; and shall be not less than fifteen (15) pounds per square foot of roadway.

The following weights are to be used in computing the dead load:

Substance	Weight per cubic foot pounds
Steel	490
Iron, cast	450
Bronze	524
Timber (treated or untreated)	60
Concrete	144
Loose sand and earth	100
Rammed sand or gravel and ballast	120
Macadam or gravel, rolled	140
Cinder filling	60
Pavement, other than wood block	150
Railway rails and fastenings	150 lbs. per ft. of track

88.03. **Live Load. Highway Live Loads:** The highway live load on the roadway portion of the bridge structure shall consist of trains of motor trucks, or equivalent loads, as hereinafter specified. Each loading is designated by the letter, H., followed by a numeral indicating the gross weight in tons of the heaviest truck involved in the loading.

88.04. **Traffic Lanes:** The truck trains or equivalent loads shall be assumed to occupy traffic lanes, each having a width of none (9) feet corresponding to the standard truck clearance width. Within the curb to curb width of roadway the traffic lanes shall be assumed to occupy any position, not involving overlapping of adjacent lanes, which will produce maximum stress. The extreme position of a lane with reference to the curb shall be that in which its outside clearance is in the vertical plane passing through the roadway edge of the curb.

88.05. **Standard Trucks:** The wheel spacing, weight distribution and clearance of the standard trucks used for design purposes shall be shown in Figure 2. As used in this specification, the weight of a truck indicates its gross loaded weight. Trucks in trains shall be spaced as shown in Figure 3.

88.06. **Standard Loadings:** The standard loadings shall be of three classes: namely, H20, H15, and H10, and may be either truck train loadings or equivalent loadings. Loadings H15 and H10 are 75% and 50%, respectively, of Loading H20.

(2) **Truck Train Loadings:** The truck train loading shall be as shown in Figure 3 and shall consist of one truck of the gross weight indicated by the loading classification, followed by or preceded by or both followed and preceded by a line of trucks of indefinite length, each of the following or preceding trucks having a gross weight of three-fourths of the gross weight indicated by the loading classification.

Trucks in adjacent lanes shall be considered as headed in the same direction.

(b) **Equivalent Loadings:** Equivalent loadings shall be used only for span lengths of sixty (60) feet or more. For span lengths of less than sixty (60) feet, the truck train loadings shall be used. The equivalent loading shall be as shown in Figure 4 and shall consist of a uniform load per linear foot of traffic lane combined with a single concentrated load so located longitudinally in the lane as to produce maximum stress. The concentrated load shall be considered as uniformly distributed across the lane on a line normal to the direction of the lane. For the computation of moments and shears different concentrated loads shall be used as indicated in Fig. 4.

88.07. **Selection of Loadings:** For the different classes of bridges the classes of loadings shall be as follows:

Class of Bridge	Class of Loading
AA	H20
A	H15
B	H10

88.08. **Application of Loads:** The loadings shall be applied in such manner as to produce maximum stress by either of the following two methods, due consideration being given to the reduced load intensities hereinafter specified for roadways wider than eighteen (18) feet.

1. Each traffic lane loading shall be considered as a unit and the number and position of the loaded lanes shall be such as will produce maximum stress.

2. The roadway shall be considered as uniformly loaded over its entire width with a load per foot of width equal to one-ninth (1/9) of the load of one traffic lane.

88.09. **Reduction in Load Intensity:** When the loaded width of roadway exceeds eighteen (18) feet the specified loads shall be reduced one per cent (1%) for each foot of loaded roadway width in excess of eighteen (18) feet with a maximum reduction of twenty-five per cent (25%) corresponding to a loaded roadway width of forty-three (43) feet. When the loads are lane loads the loaded width of roadway shall be the aggregate width of the lanes considered; when the loads are uniformly distributed over the entire width of roadway, the loaded width of roadway shall be the full width of roadway between curbs.

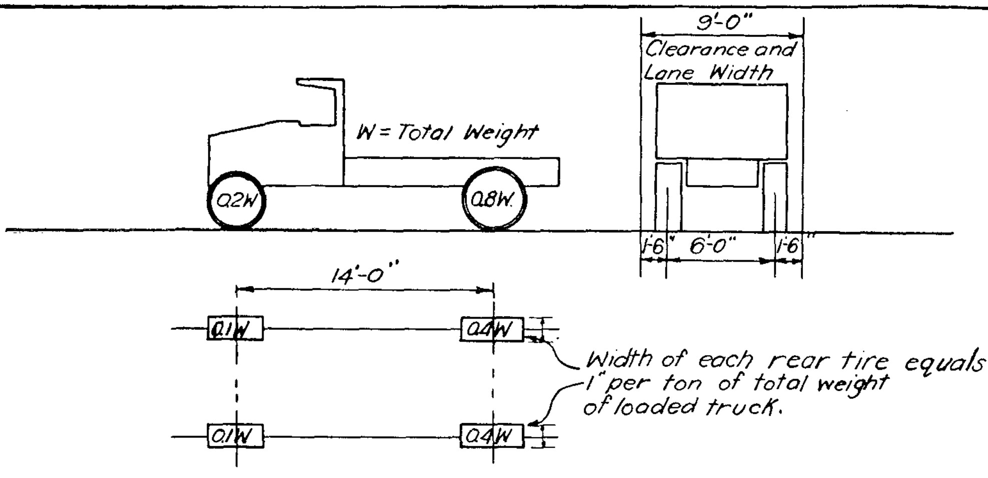
88.10. **Electric Railway Loads:** When highway bridges carry electric railway traffic, the railway loading shall be determined on the bases of the class of traffic which may be expected to operate. The possibility that the freight rolling stock of steam railroads may be operated shall be given consideration.

When not otherwise specified, the electric railway loading on each track shall be a train of two electric cars followed by, or preceded by, or both followed and preceded by, a uniform load. The cars shall be one of the classes shown in Figure 5. These cars are designated by numerals indicating the total loaded weight of each car. The uniform load per foot of track following or preceding electric cars shall be the uniform load corresponding to the class of highway loading specified six hundred forty (640 pounds per linear foot for H20 Loading). The portion of the roadway width assumed to be occupied by the railway loading shall have a width of ten (10) feet.

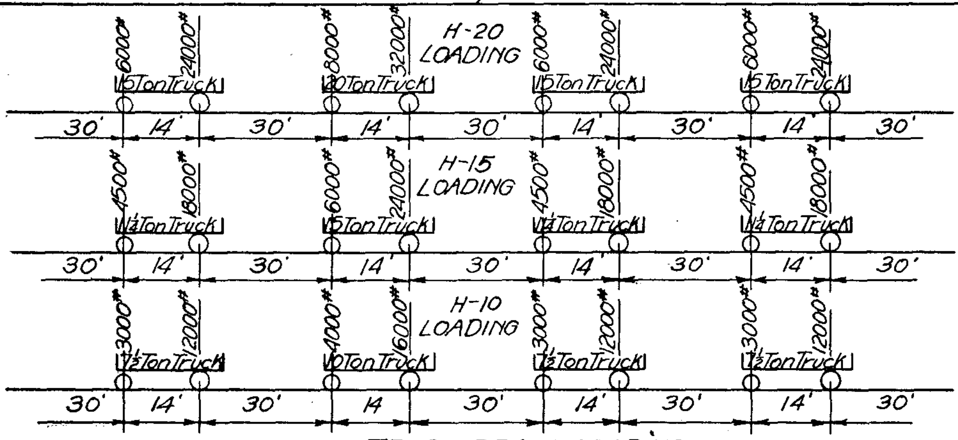
For freight car loading, the typical cars shown in Figure 6 may be assumed in the absence of more exact data.

The railway loading used shall be shown on the stress sheets.

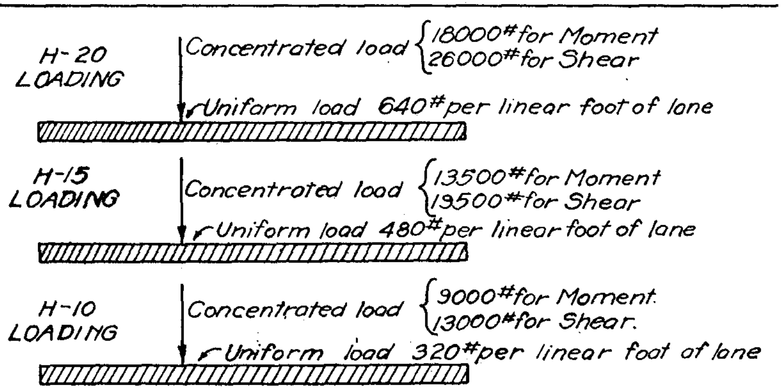
Highway bridges carrying electric railway traffic shall be designed for the following loading conditions:



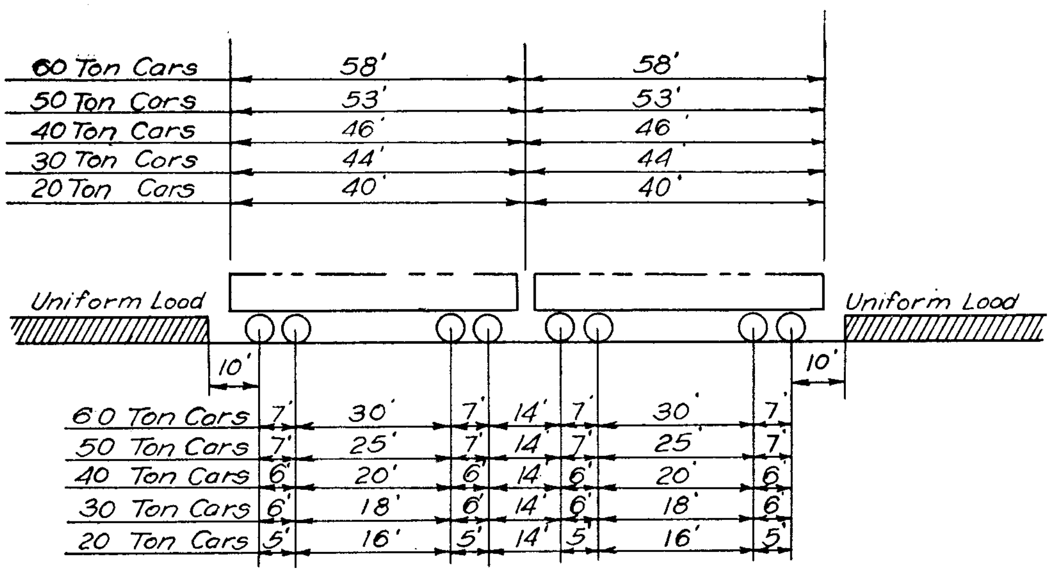
STANDARD TRUCK
Fig. 2



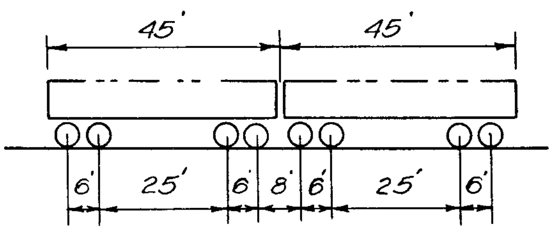
TRUCK-TRAIN LOADING
Fig. 3



EQUIVALENT LOADING
Fig. 4



ELECTRIC RAILWAY LOADING
Fig. 5



TYPICAL FREIGHT CARS

Total Loading Weight per car, including 10% overload

40 Ton Capacity	-	128,000#
50 " "	-	152,000#
60 " "	-	176,000#
70 " "	-	200,000#
80 " "	-	224,000#

Fig. 6

1. The highway loads upon any portion of the roadway area including that portion occupied by the railway.
2. The electric railway loads on the car tracks and the highway loads on the remaining traffic lanes.

88.11. **Sidewalk Loading:** All sidewalk floors, stringers and their immediate supports shall be designed to support a live load of not less than one hundred (100) pounds per square foot of sidewalk area.

Girders or trusses of highway bridges also supporting sidewalks shall be designed for a sidewalk live load determined by the following formula:

$$P = \left(40 + \frac{3000}{L}\right)\left(\frac{55 - W}{50}\right)$$

Where P = live load in pounds per square foot of sidewalk area, but not to exceed, one hundred (100) pounds per square foot.
L = loaded length of sidewalk in feet.
W = width of sidewalk in feet.
No impact increment shall be added to sidewalk loads.

Foot bridges shall be designed for a live load of one hundred (100) pounds per square foot without impact.

In calculating stresses in structures which support cantilevered sidewalks, the sidewalk shall be considered as fully loaded on one side of the structure only, when this condition produces maximum stress.

88.12. 4. **Impact:** Except in timber structures, all live load stresses, except those due to sidewalk loads and centrifugal, tractive and wind forces, shall be increased by an allowance for dynamic, vibratory and impact effects.

The amount of this allowance or increment is expressed as a fraction of the live load stress and for both electric railway and highway loadings is determined by the formula:

$$I = \frac{50}{L + 125}$$

Where I = impact fraction.
L = the length in feet of the portion of the span which is loaded to produce the maximum stress in the member.

88.13. 5. **Longitudinal Force:** Provision shall be made for the effect of a longitudinal force of ten (10%) per cent of the live load on the structure, applied four feet above the floor.

In viaduct towers the sections of members of longitudinal bracing shall be not less than those of members in corresponding panels of the transverse bracing.

88.14. **Lateral Forces:**

(a) The wind force on the structure shall be assumed as a moving horizontal load equal to thirty (30) pounds per square foot on one and one-half (1½) times the area of the structure as seen in elevation including the floor system and railing, and on one-half (½) the area of all trusses or girders in excess of two in the span.

(b) The lateral force due to the moving live load and the wind pressure against it, shall be considered as applied six (6) feet above the roadway and shall be as follows:

Highway bridges, 200 pounds per linear foot.

Highway bridges carrying electric railway traffic, 300 pounds per linear foot.

(c) The total assumed wind force shall be not less than three hundred (300) pounds per linear foot in the plane of the loaded chord and one hundred and fifty (150) pounds per linear foot, in the plane of the unloaded chord in truss spans, and not less than three hundred (300) pounds per linear foot of span in girder spans.

(d) In calculating the uplift, due to the above lateral forces, in the posts and anchorages of viaduct towers, highway viaducts shall be considered as loaded on the leeward traffic lane with a uniform load of four hundred (400) pounds per linear foot of lane and viaducts carrying electric railway traffic in addition to highway traffic shall be considered as loaded on the leeward track with a uniform load of eight hundred (800) pounds per linear foot of track.

(e) A wind pressure of fifty (50) pounds per square foot on the unloaded structure, applied as specified above in Paragraph (a), shall be used when it produces greater stresses than the combined wind and lateral forces of Paragraphs (a) and (b).

88.15. **Centrifugal Force:** Structures carrying electric railway traffic on a curve shall be designed to resist a lateral force equivalent to ten (10%) per cent of the moving railway loads, without impact; and this lateral force shall be considered as applied four (4) feet above the top of the rail.

88.16. **Forces of Stream Current and Drift:** All piers and other portions of structures which are subjected to the force of flowing water or drift shall be designed to resist the maximum stresses induced thereby.

88.17. **Pressure from Retained Material:** Structures designed to retain fills shall be proportioned to withstand pressures as given by Rankine's formula, provided, however, that no structure shall be designed for an equivalent fluid pressure of less than thirty (30) pounds per cubic foot. The above dead load pressure shall be increased to provide for any live load surcharge which may exist.

All designs shall provide for the thorough drainage of backfilling material by means of weep holes with French drains, or other suitable means.

88.18. **Thermal Forces:** In fixed arched spans, provision shall be made for the stresses resulting from the following variations in temperature:—

(a) **Metal Structures:** Moderate climate, from 0 degrees to + 120 degrees Fahr.

The rise and fall in temperature shall be figured from an assumed mean temperature at time of erection.

(b) **Concrete Structures:** Moderate climate, 30 degrees F. rise. 40 degrees F. fall.

SECTION 89.

UNIT STRESSES

89.01. **General:** Except as otherwise provided herein, the several parts of a structure shall be so proportioned that the unit stresses will not exceed the following. Unless otherwise noted, all unit stresses are given in pounds per square inch.

89.02. **STEEL STRUCTURES**

Structural Grade and Rivet Steel:

(a) **Tension:**

Axial tension, structural members, net section........16,000
Rivets in tension, where permitted........50% of single shear values
Bolts, area at root of thread........10,000

(b) **Axial Compression:**

Axial compression, gross section........ $\dfrac{16000}{1+\dfrac{1}{13500}\left(\dfrac{L}{r}\right)^2}$

but not to exceed the value of $L/r = 40$.
L = length of member, in inches.
r = least radius of gyration, in inches.

(c) **Bending on Extreme Fiber:**

Rolled shapes, built sections and girders, net section........16,000
Pins........24,000

Compression in flanges of beams and plate girders........ $\dfrac{16000}{1+\dfrac{1}{2,000}\left(\dfrac{L}{b}\right)^2}$

L = length, in inches of the unsupported flange between lateral connections of knee braces.
b = flange width, in inches.

(d) **Shear:**

Girder webs, gross section........10,000
Pins and shop driven rivets........12,000
Power driven field rivets and turned bolts........10,000
Hand driven rivets and unfinished bolts........ 8,000

(e) **Bearing:**

Pins, steel parts in contact and shop driven rivets........24,000
Power driven field rivets and turned bolts........20,000
Hand driven rivets and unfinished bolts........16,000
Expansion rollers, pounds per linear inch where d = diameter of roller in inches 600d

(f) **Countersunk Rivets:**

In metal three-eighths (3/8) inch thick and over, half the depth of countersink shall be omitted calculating bearing area.

In metal less than three-eighths (3/8) inch thick, countersunk rivets shall not be assumed to carry stress.

(g) **Diagonal Tension:**

In webs of girders and rolled beams, at sections where maximum shear and bending occur simultaneously........16,000

89.03. OTHER METALS

(a) **Axial Tension:**
Wrought-Iron 12,000

(b) **Bending on Extreme Fiber:**
Cast Steel 12,000
Cast Iron 3,000

(c) **Shear:**
Cast Steel 10,000
Cast Iron 3,000

(d) **Bearing:**
Cast Steel 14,000
Cast Iron 10,000
Bronze sliding expansion bearings 3,000

89.04. **Bearing on Bridge Seats:**
Bearing on concrete masonry, limestone masonry and better 500

CONCRETE STRUCTURES

89.05. **Concrete.**

89.06. (a) **Direct Compression:** Columns reinforced with longitudinal bars and separate lateral ties 600-15L/D
but not to exceed 450
Where L = unsupported length of column.
D = least diameter of column.
Piers and Pedestals 450

(b) **Compression Due to Bending:**
Beams and Slabs 650
Arch Rings, including temperature and rib shortening 1,000

(c) **Tension** .... Zero

(d) **Shear (Diagonal Tension):**
Beams without shear reinforcement,
Longitudinal bars not anchored 40
Longitudinal bars anchored 60
Beams with shear reinforcement 120

(e) **Punching Shear** 120

89.07. **Reinforcement.**

(a) **Tension:**

Beams and slabs 16,000
Arch rings, including temperature and rib shortening 20,000

(b) **Compression:** Fifteen (15) times stress is surrounding concrete.

(c) **Bond:**

Bars not anchored 80
Bars adequately anchored by hooks or otherwise 120

Note: The above allowable unit stress values for concrete and for bond on reinforcement are based on an ultimate compressive strength value of twenty-two hundred (2200) pounds per square inch at the age of 28 days when tested in accordance with the Tentative Standard Method of Sampling and Testing of the American Association of State Highway Officials.

When the aggregate used and the laboratory and field control of concrete mixture are such that a uniformly higher ultimate compressive strength is insured, then the above unit stresses may be increased by a maximum of fifteen per cent (15%) for concrete having an ultimate strength of twenty-eight hundred (2800) pounds per square inch or more at the age of 28 days and proportionally for intermediate values of ultimate strength, except that the stress due to bending in arch ribs when the effects of temperature and rib shortening are included shall in no case exceed one thousand (1000) pounds per square inch. When economy may be obtained by the use of aggregates which will result in concrete having a lower ultimate strength than twenty-two hundred (2200) pounds per square inch at the age of 28 days, the above unit stresses shall be reduced in the proportion that the lower ultimate strength in pounds per square inch bears to 2200.)

89.08. **Bearing Power of Soils:** For the design of foundations, the following unit bearing values may be assumed in the absence of definite information as to the actual bearing power of the foundation in question. In this tabulation it is intended to cover only broad basic groups of materials and to specify for these a maximum range in bearing power. These groups may be further subdivided to provide for special conditions.

Material	Safe Bearing Power Tons per sq. foot Min.	Max.
Alluvial soils	½	1
Clays	1	4
Sand, confined	1	4
Gravel	2	4
Cemented sand and gravel	5	10
Rock	5	....

89.09. **TIMBER STRUCTURES**

89.10. **Structural Grades of Timber:**

(a) The following unit stresses for structural grades of timber are for use with computed stresses which contain no allowance for live load impact:

Species of Wood	Axial tension and bending in extreme fiber		Compression parallel to grain short columns Cs		Compression perpendicular to grain all grades Cp	Horizontal shear in beams		Ultimate modulus of elasticity all grades
	Select	Common	Select	Common		Select	Common	
Cypress, Southern Red or Black	1200	900	1000	800	250	100	80	1,400,000
Gum, Black	900	750	750	625	200	100	80	1,200,000
Oak, Red and White	1200	1000	900	750	375	125	105	1,500,000
Pine, Southern Yellow	1400	1100	1000	800	225	110	90	1,600,000
Pine, Southern Yellow Dense Select	1600	....	1150	....	275	110	....	1,600,000

Values for Direct Shear parallel to Grain in details of joints may be taken greater than the values for Horizontal Shear in Beams.

(b) **Axial Compression in Timber Columns:**

$$p = \frac{4}{3} Cs \left(1 - \frac{L}{40D}\right)$$

The value of "p" shall not exceed the value of "Cs."

p = Unit compressive stress in column.
Cs = Unit stress for compression parallel to grain in short columns.
L = Unsupported length of column.
D = Least diameter of column.

(c) **Bearing on Inclined Sufaces:**

$$p = Cp + (Cs - Cp) \frac{\theta^2}{8100}$$

p = Unit bearing stress on inclined surface.
Cp = Unit stress for compression perpendicular to grain.
Cs = Unit stress for compression parallel to grain in short columns.
θ = Angle in degrees between bearing surface and direction of fibers (or axis of piece.)

(d) **Horizontal Shear in Beams:**

Horizontal shear in beams shall be computed from the maximum shear occurring at a distance from the support equal to three (3) times the depth of the beam.

SECTION 90

DISTRIBUTION OF LOADS

90.01. **Through Earth Fills:** When the depth of fill is three (3) feet or more, concentrated loads shall be considered as uniformly distributed over a square, the sides of which are equal to one and three-fourths (1¾) times the depth of fill. When such areas from several concentrations overlap, the total load shall be considered as uniformly distributed over the area defined by the outside limits of the individual areas, but the total width of distribution shall not exceed the total width of the supporting slab. For single spans the effect of live load may be neglected when the depth of fill is more than four (4) feet and exceeds the span length; for multiple spans it may be neglected when the depth of fill exceeds the distance between faces of end supports or abutments.

90.02. **In Concrete Slabs:** In calculating bending stresses due to wheel loads on concrete slabs, no distribution in the direction of the span of the slab shall be assumed. In the direction perpendicular to the span of the slab, the wheel load shall be considered as distributed uniformly over a width of slab which is known as the "effective width."

In the following equations let

S = span of slab in feet.
W = width of wheel or tire in feet.
X = distance in feet from the center of the nearest support to the center of wheel.
E =effective width in feet for one wheel.

Case 1. Main Reinforcement Parallel to Direction of Traffic.

$$E = 0.7\,S + W$$

For this case the value of "E" shall not exceed seven (7) feet.

When two wheels are so located on a transverse element of the slab that their effective widths overlap, the effective width for each wheel shall be ½ (E+ a), where "a" is the distance between centers of wheels.

Case 2. Main Reinforcement Perpendicular to Direction of Traffic.

$$E = 0.7\,(2x + W)$$

For this case the bending movement on a strip of slab one (1) foot in width shall be determined by placing the wheel loads in the position to produce maximum bending; determining the effective width for each wheel; and assuming the load delivered by each wheel to the one (1) foot strip to be the wheel load divided by its respective effective width.

This design assumption does not provide for the effect of loads near unsupported edges. Therefore, at the ends of the bridge and at intermediate points where the continuity of the slab is broken, the edges of the slab shall be supported by diaphragms or other suitable means.

90.03. **In Flat Slabs Supported on Four Sides:** In the case of flat slabs supported along four edges and reinforced in both directions, the proportion of the load carried by the short span of the slab shall be assumed as given by the following equations:

Load Uniformly Distributed

$$p = \frac{b^4}{a^4 + b^4}$$

Load Concentrated at Center

$$p = \frac{b^3}{a^3 + b^3}$$

Where p = proportion of load carried by short span.
a = length of short span of slab.
b = length of long span of slab.

When the length of the slab exceeds one and one-half (1½) times its width, the entire load shall be assumed to be carried by the transverse reinforcement.

In placing the reinforcement in such slabs, consideration shall be given to the fact that the bending moment is greater near the center of the slab than near the edges. Also, in the design of the supporting beams, consideration shall be given to the fact that the loads delivered to the supporting beams are not uniformly distributed along the beams.

90.04. **In Longitudinal Beams or Stringers and in Transverse Floorbeams:**

90.05. **Shear:** In calculating end shears and end reaction in transverse floorbeams and longitudinal beams and stringers, no lateral or longitudinal distribution of the wheel load shall be assumed.

90.06. **Bending Movement in Longitudinal Beams or Stringers:** In calculating bending moments in longitudinal beams or stringers, no longitudinal distribution of the wheel loads shall be assumed. The lateral distribution shall be determined as follows:

(a) **Interior Stringers:** Interior stringers shall be proportioned for loads determined in accordance with the following table except that when the limiting stringer spacings are exceeded the stringer loads shall be determined by the reactions of the truck wheels, assuming the flooring between stringers to act as a simple beam.

Kind of Floor	Floor designed for one truck		Floor designed for two trucks	
	Fraction of a wheel load to each stringer	Limiting stringer spacing in feet	Fraction of a wheel load to each stringer	Limiting stringer spacing in feet
Plank	$\frac{S}{4.0}$	4.0	$\frac{S}{3.5}$	5.0
Strip 4″ in thickness or wood block on 4″ plank subfloor	$\frac{S}{4.5}$	4.5	$\frac{S}{3.75}$	5.5
Strip 6″ or more in thickness	$\frac{S}{5.0}$	5.0	$\frac{S}{4.0}$	6.0
Concrete	$\frac{S}{6.0}$	6.0	$\frac{S}{4.5}$	10.0

S = spacing of stringers in feet.

(b) **Outside Stringers:** The live load supported by outside stringers shall be the reaction of the truck wheels, assuming the flooring to act as a simple beam between stringers.

(c) **Total Capacity of Stringers:** The combined load capacity of the beams in a panel shall not be less than the total live and dead load in the panel.

90.07. **Bending Moment in Floorbeams:** In calculating bending moments in transverse floorbeams, no transverse distribution of the wheel loads shall be assumed.

Distribution of Wheel Load on Floorbeams: When longitudinal stringers are omitted and the floor is supported directly on the floorbeams, the latter shall be proportioned for a fraction of the wheel loads as indicated in the following table, except that when the limiting floorbeam spacing is exceeded the floorbeam loads shall be determined by the reactions of the truck wheels, assuming the flooring between floorbeams to act as a simple beam.

Kind of Floor	Fraction of axle loads to each floor beam	Limiting floorbeam spacing in feet
Plank	$\frac{S}{4.0}$	4.0
Strip 4″ in thickness or wood block on 4″ plank sub-floor	$\frac{S}{4.5}$	4.5
Strip 6″ or more in thickness	$\frac{S}{5.0}$	5.0
Concrete	$\frac{S}{6.0}$	6.0

90.08. **Distribution of Electric Railway Wheel Loads:** Electric railway wheel loads may be assumed to be uniformly distributed longitudinally over a length of three (3) feet. In case of ballasted floors, a lateral distribution of ten (10) feet for an axle load may be assumed.

90.09. **Transmission of Dead Load of Fills to Culverts and Short Span Slabs:** All culverts and short span slab structures carrying a superimposed earth fill shall be proportioned to carry the entire weight of all the filling material directly above the structure.

SECTION 91

SUBSTRUCTURES AND RETAINING WALLS

91.01. **Piles:**

(a) **Use of Piling:** In general, piling shall be used when footings cannot, at a reasonable expense, be founded on rock or other solid foundation material. In streams where erosion is possible, piling preferably shall be used (if possible to drive) as a protection against scour, even though the safe wearing resistance of the natural soil is sufficient to support the structure without piling.

(b) **Design Loads:** Preferably, structures shall be proportioned to limit the maximum design load on timber piles to eighteen (18) tons per pile. In no case shall they be designed to support more than twenty-two (22) tons per pile. The maximum design load on concrete piles may be assumed as from twenty-five (25) to thirty-five (35) tons per pile, depending on conditions.

Piles shall be designed to carry the entire superimposed load, no allowance being made for the supporting value of the material between the piles.

The supporting power of piles shall be determined by the application of test loads or by the use of formulas as specified in Section 75.

(c) **Spacing:** Footing areas shall be so proportioned that pile spacing shall be not less than two feet six inches (2′-6″), center to center. The distance from the side of any pile to the nearest edge of the footing shall be not less than nine (9) inches.

(d) **Batter Piles:** When it is necessary to use piles under arch abutments, batter piles shall be used.

(e) **Concrete Piles:** Precast concrete piles shall be of approved size and shape. If a square section is employed, the corners shall be chamfered at least one (1) inch. Piles preferably shall be cast with a driving point and for hard driving preferably shall be shod with a metal shoe of approved pattern. Piling may be either of uniform section or tapered. In general, tapered piling shall not be used for trestle construction except for that portion of the pile which lies below the ground line; nor shalltapered piles be used in any location where the piles are to act as columns. In general, concrete piles shall have a cross sectional area, measured above the taper, of not less than one hundred and forty (140) square inches and when they are to be used in salt water they shall have a cross sectional area of not less than two hundred and twenty (220) square inches.

Reinforcement for precast concrete piling shall consist of longitudinal bars in combination with lateral reinforcement in the form of hoops or spirals. The longitudinal reinforcement shall be not less than one per cent and preferably not less than one and one-half per cent of the total cross-section of the pile. The reinforcement shall be placed at a clear distance from the face of the pile of not less than two (2) inches and when the piles are for use in salt water or alkali soils this clear distance shall be not less than three (3) inches. The driving point and also the top of the pile shall be protected against impact by means of special spiral winding or bands designed for this purpose. The reinforcing system preferably shall be of the "unit" type rigidly wired or fastened at all intersections. When piles exceed fifty-five (55) feet in length, additional longitudinal reinforcement shall be added throughout the central one-third (1/3) of the length. Piling under retaining walls, arch footings, abutments, etc., shall be designed to withstand the lateral stresses induced.

91.02. **Footings.**

(a) **Depth:** The depths of footings shall be determined with respect to the character of the foundation materials and the possibility of undermining. Except where solid rock is encountered or in other special cases, the footings of all structures, other than culverts, which are exposed to the erosive action of stream currents preferably shall be founded at a depth of not less than four (4) feet below the permanent bed of the stream. Stream piers and arch abutments preferably shall be founded at a depth of not less than six (6) feet below stream bed. The above preferred minimum depths shall be increased as conditions may require.

Footings not exposed to the action of stream currents shall be founded on a firm foundation and at a depth below frost.

Footings for culverts shall be carried to an elevation sufficient to secure a firm foundation, or a heavy reinforced floor shall be used to distribute the pressure over the entire horizontal area of the structure. In any location liable to erosion, apron or cut-off walls shall be used at both ends of the culvert and, where necessary, the entire floor area between the wing walls shall be paved. Baffle walls or struts across the unpaved bottom of a culvert barrel shall not be used where the stream bed is subject to erosion. When conditions require, culvert footings shall be reinforced longitudinally.

(b) **Anchorage:** Footings on solid rock, unless they are restrained by an overburden of resistant material shall be effectively anchored by means of anchor bolts, dowels, keys or other suitable means.

(c) **Distribution of Pressure:** All footings shall be designed to keep the maximum soil pressures within safe bearing values. In order to prevent unequal settlement, footings shall be designed to keep the pressure as nearly uniform as practicable. In footings having unequal pressures and requiring piling, the spacing of the piles shall be such as to secure as nearly equal loads on each pile as may be practicable.

(d) **Spread Footings:** Spread footings which act as cantilevers may be decreased in thickness from the junction of the footing slab with column or wall toward the edge of the footing, provided sufficient section is maintained at all points to provide the necessary resistance to diagonal tension and bending stresses. This decrease in section may be accomplished by sloping the upper surface of the footing or by means of vertical steps. Stepped footings shall be cast monolithically.

Except in small structures, no footing shall have a thickness at the edge of less than two (2) feet. When piles are used, the footing shall have an edge thickness of not less than eighteen (18) inches above the tops of the piles.

(e) **Internal Stresses in Spread Footings:** Spread footings shall be considered as under the action of downward forces, due to the superimposed loads, resisted by an upward pressure exerted by the foundation material and distributed over the area of the footings as determined by the eccentricity of the resultant of the downward forces. Where piles are used under footings, the upward reaction of the foundation shall be considered as a series of concentrated loads applied at the pile centers, each pile being assumed to carry its computed proportion of the total footing load.

Footings shall be designed for bending stresses, for diagonal tension stresses, and for punching shear around the periphery of the column or pier shaft. The critical section for bending shall be taken at the face of the column, wall or pier shaft. Bending need not be considered unless the projection of the footing is more than two-thirds (2/3) the depth.

When a single spread footing supports a column, pier or wall, this footing shall be assumed to act as a cantilever. When two or more piers or columns are placed upon a common footing, the footing slab shall be designed for the actual conditions of continuity and restraint.

(f) **Reinforcement:** Footing slabs shall be reinforced for bending stresses and, where necessary, for diagonal tension. All bars shall be effectively anchored to develop in bond the computed stress in the bar.

The reinforcement for square footings shall consist of two or more bands of bars. The reinforcement necessary to resist the bending moment in each direction in the footing shall be determined as for a reinforced concrete beam; the effective depth of the footing shall be the depth from the top to the plane of the reinforcement. The required reinforcement shall be spaced uniformly across the footing, unless the footing width is greater than the side of the column or pedestal plus twice the effective depth of the footing, in which case the width over which the reinforcement is spread may equal the width of the column or pedestal plus twice the effective depth of the footing plus one-half (½) the remaining width of the footing. In order that no considerable area of the footing shall remain unreinforced, additional bars shall be placed outside of the width specified, but such bars shall not be considered as effective in resisting the calculated bending moment. For the extra bars a spacing double that used for the reinforcement within the effective belt may be used. When reinforcement is used in more than one direction the allowable unit bond stresses shall be reduced as follows:

For two-way reinforcement	25%
For each additional direction	10%

(g) **Transfer of Stress from Vertical Reinforcement:** The stresses in the vertical reinforcement of columns or walls shall be transferred to the footings by extending the reinforcement into them a sufficient distance to develop the strength of the bars in bond, or by means of dowels anchored in the footings and overlapped or fastened to the vertical bars in such manner as to develop their strength. If the dimensions of the footings are not sufficient to permit the use of straight bars, the bars may be hooked or otherwise mechanically anchored in the footings.

91.03. Abutments.

(a) **General** Abutments shall be designed to withstand earth pressure, the weight of abutment and superstructure, live load over any portion of the superstructure or approach fill, wind forces, and tractive force when the latter exists. The design shall be investigated for any combination of these forces which may produce the most severe condition of loading.

Abutments shall be designed to be safe against overturning about the toe of the footing, against sliding on the footing base and against crushing of foundation material or overloading of piles at the point of maximum pressure.

In computing stresses in abutments, the weight of filling material directly over an inclined or stepped rear face, or over a reinforced concrete spread footing extending back from the face wall, may be considered as part of the effective weight of the abutment. In the case of a spread footing, the rear projection shall be designed as a cantilever supported at the abutment stem and loaded with the full weight of the superimposed material.

The cross section of stone masonry or plain concrete abutments shall be proportioned to avoid the introduction of tensile stress in the material.

(b) **Reinforcement for Temperature:** Except in gravity abutments, not less than one-eighth (0.125) square inch of horizontal reinforcement per foot of height shall be provided near exposed surfaces not otherwise reinforced, to resist the formation of temperature and shrinkage cracks.

(c) **Wing Walls:** Wing walls shall be of sufficient length to retain the roadway embankment to the required extent and to furnish protection against erosion. For ordinary materials, in the absence of accurate data, the slope of the fill shall be assumed as one and one-half (1½) horizontal to one (1) vertical and wing lengths computed on this basis.

(d) **Drainage:** The filling material behind abutments shall be effectively drained by weep holes with French drains, placed at suitable intervals.

91.04. Retaining Walls.

(a) **General:** Retaining walls shall be designed to withstand earth pressure, including any live load surcharge, and the weight of the wall, in accordance with the general principles specified above for abutments.

Stone masonry and plain concrete walls shall be of the gravity type. Reinforced concrete walls may be of either the cantilever, counterforted, buttressed, or cellular type.

(b) **Base or Footing Slabs:** The rear projection or heel of base slabs shall be designed to support the entire weight of the superimposed material.

The base slabs of cantilever walls shall be designed as cantilevers supported by the wall.

The base slabs of counterforted and buttressed walls shall be designed as fixed or continuous beams of spans equal to the distance between counterforts or buttresses.

(c) **Vertical Walls:** The vertical stems of cantilever walls shall be designed as cantilevers supported at the base.

The vertical or face walls of counterforted and buttressed walls shall be designed as fixed or continuous beams. The face walls shall be securely anchored to the supporting counterforts or buttresses by means of adequate reinforcement.

(d) **Counterforts and Buttresses:** Counterforts shall be designed as T-beams. Buttresses shall be designed as rectangular beams. In connection with the main tension reinforcement of counterforts there shall be a system of horizontal and vertical bars or stirrups to effectively anchor the face wall and base slab. These stirrups shall be anchored as near the outside faces of the face walls, and as near the bottom of the base slab, as practicable.

(e) **Reinforcement for Temperature:** Except in gravity walls, not less than one-eighth (0.125) square inch of horizontal reinforcement per foot of height shall be provided near exposed surfaces not otherwise reinforced, to resist the formation of temperature and shrinkage cracks.

(f) **Expansion Joints:** Expansion joints shall be provided at intervals not exceeding thirty (30) feet for gravity walls and fifty (50) feet for reinforced walls.

(g) **Drainage:** The filling material behind all retaining walls shall be effectively drained by weeps holes with French drains, placed at suitable intervals. In counterforted walls there shall be at least one drain for each pocket formed by the counterforts.

91.05. **Piers:**

(a) **General:** Piers shall be designed to withstand the dead and live loads superimposed thereon; wind pressure acting on the pier and superstructure; the forces due to stream current, and drift; and tractive forces at the fixed ends of spans.

Where necessary, piers shall be protected against abrasion by facing them with granite, vitrified brick, timber or other suitable material within the limits of damage by debris.

(b) **Pier Nose:** In streams carrying drift, the pier nose shall be designed as a cutwater. When a steel angle or other metal nosing is used it shall be effectively secured to the masonry by means of suitable anchor bolts having countersunk heads.

91.06. **Tubular Steel Piers:**

(a) **Use:** Preferably, tubular steel piers shall not be used and they shall never be used in locations where they will be subjected to lateral earth pressure. In special cases their use may be permitted, in which cases the following requirements shall apply.

(b) **Depth:** The general requirements governing the depths of foundations as above set forth shall govern in the case of tubular steel piers except that steel tubes resting upon gravel foundation without piling shall in no case be carried to a depth less than eight (8) feet below the permanent bed of the stream and to such additional depth as may be necessary to eliminate all danger of undermining.

(c) **Piling:** Piles used in connection with tubular steel piers shall extend into the concrete filling a sufficient distance to thoroughly brace the tubes. In general, these piles shall extend not less than six (6) to eight (8) feet above the bottom of the concrete.

(d) **Dimensions of Shell:** The minimum thickness of the metal in the shells of tubular piers shall be five-sixteenths (5/16) inch. This thickness shall be increased where necessary to secure strength and rigidity for placing the shell. In all cases the pier shall be designed for safe pile or soil bearing values as specified herein, but when the diameter required by these values is greater than that required for the superstructure bearing, the diameter may be reduced at any splice point. The minimum diameter of steel cylinders used for piers shall be forty-two (42) inches.

(e) **Splices and Joints:** All horizontal joints shall be riveted butt joints. Vertical joints may be lapped if the corners of the plates are properly scarfed. When field splicing is necessary the lower section of the tube shall extend at least two (2) feet above the water line when in position.

(f) **Bracing:** Adequate bracing connecting the tubes of cylinder piers shall be provided. In general, this bracing shall consist of a steel or concrete girder diaphragm effectively secured to the tubes. The depth of this diaphragm shall be as great as conditions will permit.

SECTION 92

STRUCTURAL STEEL DESIGN

92.01. **Spacing of Trusses and Girders:** Main trusses and girders shall be spaced a sufficient distance apart center to center, to be secure against overturning by the assumed lateral and other forces.

92.02. **Depth Ratios.** Trusses preferably shall have a depth not less than one-tenth (1/10) the span, plate girders a depth not less than one-twelfth (1/12) the span, and rolled beams a depth of not less than one-twentieth (1/20) the span. If less depths than these are used, the sections shall be increased so that the maximum deflection will not be greater than if these limiting ratios had not been exceeded.

92.03. **Dimensions for Stress Calculation:**
(a) **Effective Span:** For the calculation of stresses, span lengths shall be assumed as follows:
Beams and girders, distance between centers of bearings.
Trusses, distance between centers of end pins or of bearings.
Floorbeams, distance between centers of trusses or girders.
Stringers, distance between centers of floorbeams.

(b) **Effective Depth:** For the calculation of stresses, effective depths shall be assumed as follows:
Riveted trusses, distance between centers of gravity of the chords.
Pin-connected trusses, distance between centers of chord pins.
Plate girders, distance between centers of gravity of the flanges but not to exceed the distance back to back of flange angles.

92.04. **Reversal of Stress:** Members subject to reversal of stress during the passage of live load shall be proportioned as follows: Determine the tensile and the compressive stresses and increase each by fifty percent (50%) of the smaller; then proportion the member so that it will be capable of resisting each increased stress. The connections shall be proportioned for the sum of the actual stresses.

No pin-connected member shall be subjected to reversal of stress.

When the live load and the dead load stresses are of opposite sign, only seventy per cent (70%) of the dead load stresses shall be considered as effective in counteracting the live load stress.

92.05. **Combined Stresses:**

(a) **Axial and Bending:** Members subject to both axial and bending stresses shall be proportioned so that the combined fibre stresses will not exceed the allowable axial stress. Members continuous over panel points shall be proportioned for the live and dead load bending moments computed for a simple beam having a span equal to one (1) panel length.

(b) **Stresses due to Lateral and Longitudinal Forces and Temperature:**

In proportioning the various parts of the structure, provision shall be made for the following stress combinations:

Group A	Dead Load Live Load Impact Centrifugal Force
Group B	Lateral Force Longitudinal Force Temperature

Members subject to the stresses of Group A in combination with the stresses of Group B, either direct or flexural or both, shall be designed for any of the following combinations, at Unit Stresses 25% greater than those specified, but the resulting sections shall be not less than would be required if the stresses of Group A were considered alone.

1. The combined stresses of Group B in combinations with dead load only.
2. The combined stresses of Group A in combination with 50% of the combined stresses of Group B.
3. The combined stresses of Group A in combination with temperature only.

92.06. **Secondary Stresses:** Members and their details shall be proportioned to reduce secondary stresses to a minimum. In simple trusses without subdivided panels the secondary stresses due to deformation in any member whose width measured in the plane of flexure is less than one-tenth (1/10) of its length need not be considered. When this ratio is exceeded, or where subdivided panels are used, the secondary stresses shall be computed.

In members designed for secondary stresses in combination with other stresses the specified allowable unit stresses may be increased 30% but the sections shall be not less than required for primary stresses.

92.07. **Allowance for Overload.** For the calculation of stress reversal or counter stresses, the specified live loads, either uniform or concentrated, shall be increased one hundred percent (100%) and for this loading condition the specified unit stresses shall be increased not more than fifty percent (50%) The resulting sections shall be not less than would have been required had the allowance for overload not been considered.

92.08. **Compression Flanges of Beams and Girders:** The gross area of the compression flanges of beams and plate girders shall be not less than the gross area of the tension flanges.

The laterally unsupported length of the compression flanges of beams and girders shall not exceed forty (40) times the flange width. When the unsupported length of flange exceeds twelve (12) times the flange width, the compressive stress in pounds per square inch shall not exceed

$$19000 - 250\frac{L}{b} \quad \text{(Maximum value, 16000 lbs.)}$$

where

L = length, in inches, of unsupported flange, between lateral connections or knee braces.
b = flange width in inches.

92.09. **Proportioning Rolled Beams:** Rolled beams shall be proportioned by the moments of inertia of their sections. Proper allowance shall be made for any reduction in strength due to rivet holes in the tension flange or for any reduction in allowable stress due to the length of unsupported compression flange.

92.10. **Limiting Lengths of Members:**

(a) **Compression Members:** The ratio of unsupported length to the least radius of gyration shall not exceed one hundred and twenty (120) for main compression and stiffening members nor one hundred and forty (140) for laterals and sway bracing. In proportioning the top chords of low trusses the unsupported length shall be assumed as the length between the rigid verticals.

(b) **Tension Members:** For main riveted tension members the ratio of length to least radius of gyration shall not exceed two hundred (200).

92.11. **Effective Bearing Area:** The effective bearing area of a pin, bolt, or a rivet shall be its nominal diameter multiplied by the thickness of the metal on which it bears.

92.12. **Effective Diameter of Rivets:** In proportioning rivets, the nominal diameter of the rivet shall be used.

92.13. **Size of Rivets:** Rivets shall be of the size specified but generally shall be three-quarters (¾) inch or seven-eights (7/8) inch in diameter. Five-eights (5/8) inch rivets shall not be used in members carrying calculated stress except in two and one-half (2½) inch legs of angles and in flanges of six (6) inch and seven (7) inch beams and channels.

The diameter of rivets in angles carrying calculated stress shall not exceed one-fourth (¼) of the width of the leg in which they are driven. In angles whose size is not so determined five-eights (5/8) inch rivets may be used in two (2) inch legs, three-quarters (¾) inch rivets in two and one-half (2½) inch legs and seven-eights (7/8) inch rivets in three (3) inch legs.

In no case, except in handrails, shall structural shapes be used which do not admit the use of five-eights (5/8) inch diameter rivets.

92.14. **Pitch of Rivets:** The minimum allowable distance between centers of rivets shall be three (3) times the diameter of the rivet but preferably shall be not less than the following:

For 7/8 inch diameter rivets—3 inches.
For 3/4 inch diameter rivets—2½ inches.
For 5/8 inch diameter rivets—2¼ inches.

The maximum allowable pitch in the line of stress shall not exceed six (6) inches or sixteen (16) times the thickness of the thinnest outside plate or angle connected, except in angles having two gage lines with rivets staggered where the pitch in each line may be twice the above with a maximum of ten (10) inches.

In webs of members composed of two or more plates in contact, the rivets shall be spaced not more than ten (10) inches between centers in gage and pitch, provided such rivets serve no other purpose than to hold the plates in close contact. Tension members composed of two angles in contact shall be stitch riveted using a pitch not greater than twelve (12) inches.

92.15. **Pitch in Ends of Compression Members:** In the ends of built compression members the pitch of rivets connecting the component parts of the member shall not exceed four (4) times the diameter of the rivet for a length equal to one and one-half (1½) times the maximum width of member. Beyond this point the rivet pitch shall be gradually increased for a length equal to one and one-half (1½) times the maximum width of the member until the maximum spacing is reached. In angles having two (2) lines of staggered rivets in one leg, the pitch on each line may be twice that specified above but not greater than that allowed for the body of the member.

92.16. **Edge Distance of Rivets:** The minimum distance from the center of any rivet to a sheared edge shall be:

For 7/8 inch diameter rivets—1 1/2 inches.
For 3/4 inch diameter rivets—1 1/4 inches.
For 5/8 inch diameter rivets—1 1/8 inches.

The minimum distance from rolled or planed edges, except flanges of beams and channels, shall be:

For 7/8 inch diameter rivets—1 1/4 inches.
For 3/4 inch diameter rivets—1 1/8 inches.
For 5/8 inch diameter rivets—1 inch.

The maximum distance from any edge shall be eight (8) times the thickness of the thinnest outside plate, but shall not exceed five (5) inches.

92.17. **Long Rivets:** Long rivets subjected to calculated stress and having a grip in excess of four and one-half (4½) diameters shall be increased in number at least one (1%) percent for each additional one-sixteenth (1/16) inch of grip. If the grip exceeds six (6) times the diameter of the rivet, specially designed rivets shall be used.

92.18. **Rivets in Tension:** Rivets in direct tension shall, in general, not be used. However, where so used their value shall be one-half (½) that permitted for rivets in shear. Countersunk rivets shall not be used in tension.

92.19. **Parts Accessible.** The accessibility of all parts of a structure for inspection, cleaning and painting shall be insured by the proper proportioning of members and the design of their details.

92.20. **Open Sections and Pockets:** Closed sections shall in general be avoided. Pockets or depressions which will retain water shall be avoided as far as possible and those which are unavoidable shall be provided with effective drain holes or shall be effectively filled with waterproof material.

Details shall be arranged so that the retention of dirt, leaves or other foreign matter will be reduced to a minimum. Wherever angles are used, either singly or in pairs, they preferably shall be placed with the vertical legs extending downward.

92.21. **Symmetrical Sections:** Main members shall be proportioned so that their neutral axes shall be as nearly as practicable in the center of the section.

In general, the gravity axes of main truss and other important members, meeting to form a joint, shall intersect in a common point so as to avoid eccentricity of stress. In case of unavoidable eccentricity the members affected thereby shall be proportioned and the connection details designed to resist the stresses produced.

92.22. **Effective Area of Angles in Tension:** The effective area of single angles in tension shall be assumed as the net area of the connected leg plus fifty percent (50%) of the area of the unconnected leg.

The effective area of a double angle tension member shall be assumed as eighty (80) percent of the net area of the member unless the end details and connections are such that the individual angles are held against bending in both directions, in which case the full net area may be used. When the angles connect to separate gusset plates, as in the case of a double-webbed truss, the gusset plates shall be stiffened by diaphragms in the line of the connected angles or by tie plates extending to the ends of the angles if they are to be considered as offering such resistance to bending that the full net area can be used. When the angles are connected back to back on opposite sides of a single gusset plate the support may be assumed to be sufficient to allow the use of the full net section.

Lug angles shall not be considered as effective in transmitting stress.

92.23. **Strength of Connections:** Unless otherwise provided all connections shall be proportioned to develop not less than the full strength of the members connected.
No connections, except for lacing bars and handrails, shall contain less than three (3) rivets.

92.24. **Splices:** Continuous compression members in riveted structures, such as chords and trestle posts, shall have milled ends and full contact bearing at the splices.

All splices, whether in tension or compression, shall be proportioned to develop the full strength of the members spliced and no allowance shall be made for milled ends of compression members.

Splices shall be located as close to panel points as possible and, in general, shall be on that side of the panel point which is subjected to the smaller stress.

The arrangement of the plates, angles or other splice elements shall be such as to make proper provision for the stresses in the component parts of the members spliced.

92.25. **Indirect Splices:** In all splice plates not in direct contact with the parts they connect, the number of rivets on each side of the joint shall be in excess of the number which would otherwise be required for a contact splice to the extent of two extra transverse lines for each intervening plate.

92.26. **Fillers:** Where indirect splices involve rivets carrying stress and passing through fillers, the fillers shall be extended beyond the splicing material and the extension secured by additional rivets sufficient in number to develop the section of the filler.
When the filler is less than one-quarter (¼) inch thick the splicing material shall also be extended.

92.27. **Gusset Plates:** Gusset or connecting plates shall be used for connecting all main members, except in pin-connected structures. In proportioning and detailing these plates the rivets connecting each member shall be located, as nearly as practicable, symmetrically with the axis of the member. However, the full development of the elements of the member shall be given due consideration. The gusset plates shall be of ample thickness to resist shear, direct stress and flexure acting on the weakest or critical section of maximum stress.
Re-entrant cuts shall be avoided as far as possible.

92.28. **Minimum Thickness of Metal.** The minimum thickness of structural steel shall be five-sixteenth (5/16) inch except for fillers and railings. However, gusset plates shall not be less than three-eights (3/8) inch in thickness.

Metal subject to marked corrosive influence shall be increased in thickness, or specially protected against corrosion.

Cast steel shall not be less than one (1) inch and cast iron not less than one and one-quarter (1¼) inch thick, except for filler blocks.

92.29. **Compression Members:** In built compression members the metal shall be concentrated as much as possible in the webs and flanges, so that the center of gravity of the section may be as near the center lines of the member as practicable.

92.30. **Plates in Compression:** Cover plates of built-up compression members and cover plates on the compression flanges of plate girders shall have a minimum thickness of one-fortieth (1/40), and the web plates of compression members a minimum thickness of one-thirtieth (1/30), of the transverse distance between the lines of rivets connecting them to the flanges. However, failing to meet this requirement, the width of plate between the connecting lines of rivets in excess of forty (40) times the thickness for cover plates and thirty (30) times the thickness for web plates, shall not be considered as effective in resisting stress.

92.31. **Outstanding Flanges:** Outstanding compression flanges of girders and main compression members shall have a minimum thickness of one-twelfth (1/12) of the width of outstanding flange. For lateral bracing and other secondary members this minimum thickness may be one-fourteenth (1/14) of the width of the outstanding flange.

92.32. **Tie Plates:** The open sides of compression members shall be provided with lacing bars and shall have tie plates as near each end as practicable and at intermediate points where the lacing is interrupted. Compression members composed of two angles and a cover plate shall have, on their open sides, ties composed of short lengths of channel section with the flanges riveted to the vertical legs of the angles.

Tension members composed of shapes shall have their separate segments connected by tie plates or by tie plates and lacing bars.

The thickness of the tie plates shall be not less than one-fiftieth (1/50) of the distance between the connecting lines of rivets. Tie plates shall be connected by not less than three (3) rivets on each side and in members having lacing bars the last rivet in the tie plate shall preferably also pass through the end of the adjacent bar.

For main compression members, the end tie plates shall have a length not less than one and one-half ($1\frac{1}{2}$) times the perpendicular distance between the lines of rivets connecting them to the member, and the intermediate tie plates a length not less than that distance. For main tension members the end tie plates shall have the length above specified for end tie plates on main compression members and the length of the intermediate tie plates shall be not less than three-quarters ($\frac{3}{4}$) the length specified for intermediate tie plates on compression members. In tension members whose elements are connected by tie plates only, the distance center to center of plates shall not exceed three (3) feet.

For lateral struts and other secondary members, the length of end and intermediate tie plates shall be not less than three-quarters ($\frac{3}{4}$) the perpendicular distance between the lines of rivets connecting them to the member.

92.33. **Lacing Bars:** The lacing of compression members shall be proportioned to resist shearing stresses normal to the member not less than those calculated by the formulas:

$$(1)\quad R = \frac{4\,I}{C\,L}\,(16000-p).$$

$$(2)\quad R = \frac{0.4\,p\,I}{C\,L}$$

In which

R = normal shearing stress in pounds.
I = moment of inertia of section about an axis perpendicular to the plane of the latticing.
C = distance from neutral axis to extreme fiber, in inches.
p = average compressive unit stress in the member; $= \frac{P}{A}$
L = length of member, in inches.

The greater of the values given by these two formulas shall be used.

If the lacing of a horizontal or inclined compression member is in a vertical plane, the shear in the lacing caused by the weight of the member shall be added to the shear calculated by the formulas above.

The shear shall be considered as divided equally among all shear resisting elements in parallel planes, whether made up of continuous plates or of lattice. The size of the bar shall be determined by the column formula Paragraph 89.02 in which "L" shall be taken as the distance between the connections to the main sections.

The minimum width of lacing bars shall be:

For 7/8 inch diameter rivets—2 1/2 inches.
For 3/4 inch diameter rivets—2 1/4 inches.
For 5/8 inch diameter rivets—2 inches.

Lacing bars having two (2) rivets in each end shall be used for flanges five (5) inches or more in width.

The minimum thickness of bars shall be one-fortieth (1/40) of the distance between end rivets in the case of single lacing and one-sixtieth (1/60) of this distance for double lacing, but not less than five-sixteenth (5/16) inch.

Double lacing, riveted at the intersections, shall be used when the perpendicular distance between rivet lines exceeds fifteen (15) inches.

The inclination of single lacing shall generally be about sixty (60) degrees and for double lacing it shall be about forty-five (45) degrees to the axis of the member. Lacing bars of compresssion members shall be so spaced that the L/r of the portion of the flange included between lacing bar connections will be not greater than forty (40), and not greater than two-thirds ($\frac{2}{3}$) of the L/r of the member.

Shapes of equivalent strength may be used instead of flats.

92.34. **Net Section at Pin Holes:** In pin-connected riveted tension members, the net section across the pin hole shall be not less than 140 per cent, and the net section back of the pin hole not less than 100 per cent of the net section of the body of the member.

92.35. **Net Section of Riveted Tension Members:** In calculating the required area of riveted tension members, net sections shall be used in all cases and, in deducting rivet holes, they shall be taken as one-eighth (1/8) inch larger than the nominal diameter of the rivet.

The net section shall be the least area which can be obtained by deducting from the gross sectional area, the area of holes cut by any straight or zigzag section across the member, counting the full area of the first hole and a fractional part of each succeeding hole, the fractional part being determined by the formula:

$$X = 1 - \frac{S^2}{4gh}$$

Where X = fraction of rivet hole to be deducted.
S = stagger or longitudinal spacing of rivet with respect to rivet on last gage line.
g = distance between gage lines, or transverse spacing.
h = diameter of rivet holes, or nominal diameter of rivet plus 1/8 inch.

92.36. **Location of Pins:** Pins shall be located, with respect to the neutral axes of the members, so as to reduce to a minimum secondary stresses due to bending.

92.37. **Pin Plates:** Pin plates shall be of sufficient thickness to provide the required bearing area upon the pin; they shall be as wide as the dimensions of the member will allow; and their length, measured from pin center to end, shall be at least equal to their width. Pin plates shall contain sufficient rivets to distribute their due proportion of the pin pressure to the full cross section of the members; only the rivets located within two lines drawn from the pin center toward the body of the member and inclined at forty-five (45) degrees to the axis of the member shall be considered effective for this purpose. In the case of members composed of web plates and flange angles (with or without a cover plate) there shall be at least one outside pin plate covering the vertical legs of the flange angles.

At the end of compression members at least one pair of pin plates shall extend not less than six (6) inches beyond the near edge of the tie plate.

All pin-connected compression members shall be provided with hinge plates having a minimum thickness of three-eights (3/8) inch.

92.38. **Forked Ends:** Forked ends on compression members will be permitted only when unavoidable. When used, a sufficient number of pin plates shall be provided to give each jaw the full strength of the compression member. At least one (1) pair of these plates shall extend to the far edge of the tie plates, and the others not less than six (6) inches beyond the near edge of the tie plates.

92.39. **Pins and Pin Nuts:** Pins shall be proportioned for the maximum shears and bending moments produced by the stresses in the members connected. If there are eye-bars among the parts connected, the diameter of the pins hall be not less than three-fourths (¾) of the width of the widest bar attached.

Pins shall be of sufficient length to secure a full bearing of all parts connected upon the turned body of the pin. They shall be secured in position by hexagonal chambered nuts or by hexagonal solid nuts with washers. Where the pins are bored, through rods with cap washers may be used. In general, malleable castings conforming to the requirements of paragraph 69.21 and 69.22 shall be used for pin nuts. Pin nuts shall be secured by cotters in the screw ends.

92.40. **Bolts:** Unless specifically authorized, bolted connections will not be permitted. Bolts, when used, shall be unfinished or turned as specified and shall meet the requirements of paragraph 69.68.

Bolts in tension shall have double nuts.

92.41. **Upset Ends.** Bars and rods with screw ends shall be upset to provide a cross sectional area at the root of the thread which shall exceed the net section of the body of the member by at least fifteen (15) percent.

93.42. **Sleeve Nuts:** Sleeve nuts shall not be used.

92.43. **Expansion:** Provision for expansion and contraction, to the extent of one eighth inch for each ten feet of span, shall be made for all bridges. Expansion ends shall be firmly secured against lifting or lateral movement.

92.44. **Expansion Bearings:** Spans of less than seventy (70) feet may be arranged to slide upon metal plates with smooth surfaces. Spans of seventy (70) feet and over shall be provided with rollers or rockers, or with the special sliding bearings described below. Neither rollers nor rockers shall be used for expansion bearings at the top of trestle posts.

92.45. **Fixed Bearings:** Fixed bearings shall be firmly anchored.

92.46. **Hinged or Pin Bearings:** Spans of seventy feet and over shall have hinged or pin bearings at both ends. The pedestals or shoes shall be so designed that all loads will act through the end pins which will be located directly over the geometrical center of the bearing.

92.47. **Rollers:** Expansion rollers shall not be less than six (6) inches in diameter for span lengths of one hundred (100) feet or less and this minimum shall be increased not less than one (1) inch for each additional one hundred (100) feet of span, and proportionately for intermediate lengths, They shall be connected together by substantial side bars and shall be effectually guided so as to prevent lateral movement, skewing or creeping. The rollers and bearing plates shall be protected from dirt and water as far as possible and the construction shall be such that water will not be retained and that the roller nests may be inspected and cleaned with the minimum difficulty.

92.48. **Rockers:** Pin bearing expansion rockers shall be of cast steel or cast iron.

92.49. **Special Sliding Expansion Bearings:** Sliding plates for the expansion bearings of spans of seventy feet and over shall be of Class A bronze conforming to the requirements of paragraph 69.23 and 69.24. These plates shall be chamfered at the ends and shall be held securely in position, usually by being inset into the metal of the pedestals and sole plates. Provision shall be made against any accumulation of dirt which will obstruct their free movement.

92.50. **Pedestals and Shoes:** Pedestals and shoes shall be designed to secure rigidity and stability and to distribute the reaction uniformly over the entire bearing area. Preferably, they shall be made of cast steel or structural steel. The bottom bearing widths shall not exceed the top bearing widths by more than twice the depth of pedestal and, when involving pin bearings, this depth shall be measured from the center of pin.

Where built pedestals and shoes are used the web-plates and the angles connecting them to the base plates shall be not less than five eights (⅝) inch thick. If the size of the pedestal permits, the webs shall be rigidly connected transversely. The minimum thickness of the metal in cast steel pedestals shall be one (1) inch.

92.51. **Inclined Bearings:** For spans on an inclined grade without pin or hinged bearings, the sole plates shall be beveled so that the sub-structure bridge seats will be level.

92.52. **Anchor Bolts:** Trusses, girders and I-beams shall be securely anchored to their substructures. Anchor bolts shall be roughened by being screw-threaded or swedged to secure a satisfactory grip upon the material used to embed them in the holes.

The following are the minimum requirements for each bearing:

For I-beam spans the outer beams shall be anchored at each end with two bolts one inch in diameter, set ten inches in the masonry.

For girder and truss spans

Spans Fifty (50′) feet in length or less, 2 bolts, 1 inch diameter, set 10 inches in masonry.
Spans 51 to 100 feet in length, 2 bolts, 1¼ inch diameter, set 1′-0″ in masonry.
Spans 101 to 150 feet in length, 2 bolts, 1½ inch diameter, set 1′-3″ in masonry.
Spans 151 feet and over, 4 bolts, 1½ inch diameter, set 1′-6″ in masonry.

Anchor bolts subject to tension, as in the column base of trestle bents and towers, shall be designed to engage a mass of masonry which will secure a resistance equal to one and one-half (1½) times the calculated uplift.

92.53. **FLOOR SYSTEM**

92.54. **Floorbeams:** Floorbeams preferably shall be at right angles to the trusses of main girders and shall be rigidly connected thereto. In general, floorbeam connections shall be located above the bottom chord and, in riveted work, the bottom chord lateral system shall engage both the bottom chord and the floorbeams. Floorbeam connections to pin connected trusses preferably shall be above the bottom chord pin but, if located below, the vertical posts shall be extended below the pins to secure rigid connections to the floorbeams.

92.55. **End Floorbeams:** Except in skew bridges end floorbeams shall be provided in all truss and girder spans. End floorbeams preferably shall be designed to permit the use of jacks for the future lifting of the superstructure, under which condition the specified unit stresses shall not be exceeded by more than fifty (50) per cent.

End floorbeams shall be arranged to permit future painting of the sides of the beams adjacent to the abutment backwalls.

92.56. **Stringers:** Steel stringers preferably shall be riveted between the floorbeams, with end connections to the floorbeam webs.

92.57. **End Struts:** When end floorbeams are not used the end panel stringers shall be secured in correct locations by end struts securely connected to the stringers and to the main trusses or girders. The end panel lateral bracing shall be rigidly attached to the main trusses or girders and shall also be attached to the end struts. Adequate provision shall be made for the expansion movement of stringers.

92.58. **End Connections for Floorbeams and Stringers:** The end connection angles of floorbeams and stringers shall be not less than three-eights (3/8) inch in thickness. When milled ends are required, the thickness of connection angles shall be one-sixteenth (1/16) inch greater than for connection angles not required to be milled. Except in cases of special end floorbeam details, end connections for floorbeams and stringers shall be made with two angles at each end. Bracket or shelf angles which may be used to furnish support during erection shall not be considered in determining the number of rivets required to transmit end shears.

End connection angles shall develop the full depth of the webs by having a length as great as the flanges will permit.

In the preparation of end connection details, special care shall be exercised to provide ample clearance for the driving of field connection rivets.

Where timber stringers frame into floor beams, shelf angles with stiffeners shall be provided to carry the whole reaction. Shelf angles shall be not less than seven-sixteenths ($\frac{7}{16}$) inch thick.

Any type of floorbeam hanger which will permit the rotation or the longitudinal motion of the floorbeam, shall not be used.

92.59. **Expansion Joints:** To provide for expansion and contraction movement, suitable floor expansion joints shall be provided at the expansion ends of all spans and at other points where they may be required.

Apron plates, when used, shall be designed to properly bridge the joint and to prevent, as far as possible, the deposit of roadway debris upon the bridge seats.

92.60. **Sidewalk Brackets:** Sidewalk brackets shall be connected directly to the top and bottom flanges of floor beams.

92.61. **BRACING**

92.62. **Design of Bracing:** Lateral, longitudinal and transverse bracing shall be composed of angles or other shapes offering resistance to deformation when subjected to compression stress, and shall have riveted connections.

In general, bracing shall consist of a double system of diagonal tension members with transverse compression members. The diagonals in each system shall be proportioned to carry the total lateral stress in tension, the transverse struts (or floorbeams) acting as compression members for both systems.

All intersections of lateral and sway bracing shall be riveted to add rigidity and prevent deformation.

92.63. **Minimum Size of Angles:** The smallest angle used in bracing shall be three by two and one-half (3x2½) inches, There shall not be less than three (3) rivets in each end connection of the angles.

92.64. **Lateral Bracing:** Bottom lateral bracing shall be provided in all bridges except I-beam spans, from which it may be omitted. Bottom laterals preferably shall be supported by rigid hangers at the intersections.

Top lateral bracing shall be provided in deck spans and in through spans having sufficient head room.

Lateral bracing for compression chords shall preferably consist of either two or four angle latticed sections; and so designed as to effectively engage both flanges of the chords.

Lateral bracing shall have concentric connections to chords at end joints, and preferably throughout. The connections between the lateral bracing and the chords shall be designed to avoid, as far as possible, any bending stress in the truss members.

92.65. **Portal and Sway Bracing:** Through truss spans shall have portal bracing, preferably of the two plane or box type, rigidly connected to the end post and top chord flanges, and constructed as deep as the minimum clearance will allow. When a single plane portal is used it preferably shall be located in the central transverse plane of the end posts, with diaphragms between the webs of the posts to provide for a proper distribution of the portal stresses. The portal bracing shall be designed to take the full end reaction of the top chord lateral system and the end posts shall be designed to transfer this reaction to the truss bearings.

Deck truss spans shall have adequate sway bracing at the ends and at all intermediate panel points. This bracing shall occupy the full depth of the trusses below the floor system. The bracing shall be proportioned to transfer the end reaction of the top lateral system to the substructure.

Through truss spans shall have sway bracing at each intermediate panel point if the height of the trusses is such as to permit a depth of five (5) feet or more for the bracing. When the height of the trusses will not permit of such depth the top lateral struts shall be provided with knee braces. Top lateral struts shall be at least as deep as the top chord. Sway bracing shall be of ample strength to transfer one-half (½) of the wind pressure to the leeward truss.

92.66. **Cross Frames:** Deck plate girder spans shall be provided with cross frames at each end proportioned to resist all lateral forces, and shall have intermediate cross frames at intervals not exceeding twenty (20) feet. These frames shall be connected to the outstanding legs of the stiffener angles and to the girder flanges.

92.67. **Low Truss Spans:** The vertical truss members and the floorbeam connections of low truss spans shall be proportioned to resist a lateral force, applied at the top chord panel points of the truss, determined by the following equations:

$$R = 150\ (A+P)$$

Where R = lateral force in pounds.
A = area of cross section of chord in square inches.
P = panel in length in feet.

This rigidity may be secured in part by extending one or both of the floorbeam connection angles upward along the inside of the post. Preferably outrigger brackets attached to the vertical posts on the outside of the trusses shall not be used.

92.68. **Through Girder Spans:** Through plate girder spans shall be stiffened against lateral deformations by means of gusset plates, or knee braces with solid webs, attached to the stiffener angles and floorbeams. If the unsupported length of the inclined edge of the gusset plate exceeds sixty (60) times its thickness, the gusset plate shall have stiffener angles riveted along its edge.

These braces generally shall extend to the clearance line and preferably shall be spaced not farther apart than fifteen (15) feet.

92.69. **Bracing of Long Columns:** The bracing of long columns shall be designed to fix the column in both the lateral and the longitudinal directions, at or near the same point.

92.70. PLATE GIRDERS

92.71. **Proportioning:** Plate girders shall be proportioned either by assuming the flanges to be concentrated at their centers of gravity or by the moment of inertia of the net section. In the former case one-eighth of the gross area of the web is available as net flange area but the effective depth shall not be assumed to be greater than the distance back to back of flange angles. For girders having unusual cross sections the moment of inertia method shall be used.

92.72. **Flange Sections:** The gross section of the compression flange shall not be less than the gross section of the tension flange. The compression flange preferably shall be stayed against lateral deflection at intervals not exceeding twelve (12) times its width.

The flange angles shall form as large a portion of the gross area of the flange as practicable.

When flange plates are used, at least one plate on the top flange shall extend the full length of the girder except where flange is to be covered with concrete. Any additional flange plates shall be of such length as to allow two rows of rivets to be placed at each end of the plate beyond its theoretical end, and there shall be a sufficient number of rivets at the ends of each plate to develop its full stress value before the theoretical end of the next outside plate is reached.

Flange cover plates shall be equal in thickness, or shall diminish in thickness from the flange angle outward. No plate shall have a thickness greater than that of the flange angles.

92.73. **Web Plates:** Web plates shall be proportioned for both the vertical and horizontal shearing stresses. The thickness of web plates, except those to be cased in concrete, shall be not less than $1/20\ \sqrt{D}$ in which D is the distance in inches between flanges.

92.74. **Flange Rivets:** The number of rivets connecting the flange angles to the web plates shall be sufficient to develop the increment of flange stress transmitted to the flange angles, combined with any load that is applied directly to the flange. For electric railways, one wheel load, when applied directly to the flange, shall be assumed to be distributed uniformly over a length of three (3) feet.

92.75. **Flange Splices:** Splices in flange parts shall not be used except by special permission of the Engineer. Two parts shall not be spliced at the same cross section and, if practicable, splices shall be located at points where there is an excess of section. The net section of the splices shall exceed by ten (10) per cent, the net section of the parts spliced. Flange angle splices shall consist of two (2) angles, one on each side. Splice angles shall be fitted to secure close contact with the material spliced.

92.76. **Web Splices:** Web plates shall be symmetrically spliced by plates on each side. The splice shall be equal in strength to the web in both shear and moment. There shall be at least two (2) rows of rivets on each side of the joint. The splice plates for shear shall be of the full depth of the girder between flanges.

92.77. **End Stiffeners:** Plate girders shall have stiffener angles over end bearings, the outstanding legs of which shall be as wide as the flange angles will allow and shall fit tightly against them. These end stiffeners shall be proportioned for bearing on the outstanding legs of the flange angles, no allowance being made for the legs fitted to the fillets of the flange angles. End stiffeners shall be arranged to transmit the total end reaction and to distribute it over the bearings. They shall not be crimped and there shall be a sufficient number of rivets in their connection to the web.

92.78. **Intermediate Stiffeners.** Intermediate stiffener angles shall be riveted in pairs to the web of the girder. The outstanding leg of each angle shall have a width of not more than sixteen (16) times its thickness and not less than two (2) inches plus one thirtieth (1/30) of the depth of the girder.

Intermediate stiffeners shall be spaced at intervals not exceeding:

(a) 6 feet;
(b) The depth of the web;
(c) The distance given by the formula,

$$d = \frac{t}{40}(12000\text{-}S)$$

Where d = distance between rivet lines of stiffeners, in inches.
t = Thickness of web, in inches.
s = Web shear, in pounds per square inch, at the point considered.

When the depth of the web between the flange angles or side plates is less than sixty (60) times the web thickness, intermediate stiffeners may be omitted.

Intermediate stiffener angles shall be placed at points of concentrated loading and shall be designed to transmit the reactions to the girder web. Such stiffeners shall not be crimped.

92.79. **Ends of Through Girders:** The upper corners of through plate girders, where exposed, shall be neatly rounded to a radius consistent with the size of the flange angles and the vertical height of the girder above the roadway. The first flange plate or a plate of the same width will be bent around the curve and continued to the bottom of the girder. In a bridge consisting of two or more spans only the corners on the extreme ends need be rounded, unless the spans have girders of varying heights, in which case the higher girders shall have their top flanges neatly curved down at the ends to meet the top corners of the girders in the adjacent spans.

92.80. **End Bearings:** End bearings of girders on masonry shall be raised above the bridge seat by metal pedestals or plates a height of at least six (6) inches.

92.81. **Sole and Masonry Plates:** Sole and masonry plates shall have a thickness not less than three-quarters (¾) of an inch and not less than the thickness of the flange angles plus one-eighth (1/8) of an inch. Preferably they shall not be longer than eighteen (18) inches.

92.82. **Camber:** In general, camber will not be required in plate girders except for long spans or special conditions. When used, it shall be sufficient in amount to meet the requirements of the Engineer.

92.83. **TRUSSES**

92.84. **Main Features:** Preference will be given to trusses with single intersecting web members or other forms of trusses possessing the least ambiguity in computed stresses and the greatest elements of service ability. Adjustable members in any part of the structure preferably shall be avoided. Members shall be symmetrical about the central planes of trusses and all parts shall be so designed that they can be inspected, cleaned and painted.

Through riveted and pin-connected spans will generally have inclined end posts. Low truss spans shall be of the riveted type. In low truss spans, laterally unsupported hip joints or "flying hips" shall be avoided.

92.85. **Top Chords and End Posts:** Top chords and end posts of low and through truss spans shall be made usually of two side segments with one cover plate and with tie plates and lacing on the open side. In chords of light section, tie plates and lacing may be used in place of a cover plate.

Top chords of deck trusses subjected to direct loading shall be designed for the cross bending occas-casioned by the dead, live and impact loads of the floor system, in addition to the direct chord stresses, and all top chord splices shall be proportioned for those stresses and any shearing stresses they may receive.

Where the shape of the truss permits, compression chords shall be built continuous, with splices located as near the panel points as possible and preferably on the side subjected to the smaller stress.

The top chord sections of low truss spans shall be so proportioned that the radius of gyration about the vertical axis of the member shall be at least one and one-half (1½) times the radius of gyration about the horizontal axis.

92.86. **Bottom Chords:** The bottom chords of riveted trusses generally shall be spliced near panel points and on the side farthest away from the center of the span.

Bottom chords composed of angles preferably shall be constructed with the vertical legs of the angles extending downward.

92.87. **Working Lines and Gravity Axes:** For compression members of unsymmetrical sections, such as chord sections formed of side segments and a cover plate, the working line shall coincide as nearly as practicable with the gravity axis of the section except that eccentricity may be introduced to counteract dead load bending. For symmetrical sections the working line shall coincide with the gravity axis. For two-angle bottom chord or diagonal members the working line may be taken as the gage line nearest the back of the angle.

92.88. **Camber:** In long spans and those designed to carry electric railways, the length of the truss members shall be such that the camber will equal the deflection produced by the dead load plus full live load without impact. Trusses shall in general be given a camber by increasing the length of the top chords an amount in each panel length equal to three-sixteenth (3/16) inch for each ten (10) feet of their horizontal projection.

92.89. **Rigid Members in Pin-Connected Trusses:** Pin connected trusses shall have stiff riveted members in the first two main panels of the bottom chords at each end of the span, and all web members performing the function of suspenders shall be of stiff riveted construction.

92.90. **Counters and Adjustable Members:** If web members are subject to reversal of stress, their end connections shall be riveted. Rigid counters are preferred. Adjustable counters, when used, shall have open turn-buckles and in the design of these members an allowance of ten thousand (10,000) pounds shall be made for initial stress. Only one set of diagonals in any panel shall be adjustable. Sleeve nuts and loop bars shall not be used.

92.91. **Eye-Bars:** Eye-Bar heads shall have a cross sectional area through the center of the pin hole exceeding that of the body of the bar by at least thirty-five (35) percent. The net section adjacent to the head shall be not less than that of the main body of the bar. The thickness of the bar shall be not less than one-eighth (1/8) of the width and not less than one-half (½) inch and not greater than two (2) inches. The form of the head shall be submitted to the Engineer for approval before the bars are made. The diameter of the pin shall be not less than three-fourths (¾) of the width of the widest bar connected.

92.92. **Packing Eye-Bars:** The eye-bars of a set shall be packed symmetrically about the central plane of the truss and as nearly parallel as practicable, but in no case shall the inclination of any bar to the plane of the truss exceed one-sixteenth (1/16) inch per foot. Bars shall be packed as closely as practicable and held against lateral movement, but they shall be arranged so that adjacent bars in the same panel will be separated by at least one-half (½) inch.

All intersecting diagonal bars not far enough apart to clear each other at all times shall be well clamped together at intersections.

Steel filling rings shall be provided, when required, to prevent lateral movements of eye-bars or other members connected upon pins.

92.93. **Diaphragms:** Diaphragms shall be provided in the trusses at the end connections of all floorbeams. In general, such diaphragms shall extend down to the bottom flange of the floorbeam and for at least two (2) rivet spaces above the top flange.

The gusset plates engaging the pedestal pin at the end of a truss shall be rigidly connected by a diaphragm which shall, in general, take direct bearing on the pin. Similarly, the pedestal webs shall, where practicable, be connected by a diaphragm which shall, in general, take bearing on the pin.

A diaphragm shall be provided between gusset plates engaging main members whenever the end tie plate is located at a distance of four (4) feet or more from the point of intersection of the members. In general, the web of this diaphragm shall be located in the place of the latticed flange.

92.94. **Sole and Masonry Plates:** Sole and masonry plates supporting trusses and columns shall each have a thickness of not less than three quarter (¾) inch. The bottom chords of trusses shall be raised above the bridge seat at least six (6) inches by the use of metal plates or pedestals.

92.95. VIADUCTS.

92.96. **Type:** Viaducts shall consist usually of alternate tower spans and free spans of plate girders or riveted trusses supported on trestle towers. However, in viaducts having a column height less than thirty-five (35) feet, trestle bents may alternate with the towers.

In viaducts requiring freedom of waterway and in structures having a less total column height than twenty (20) feet, the number of intermediate trestle bents may be increased over that specified above but, in general, shall not exceed four (4) in number. Ample rigidity shall be secured in the attachment of the superimposed spans to the column caps of the bents.

92.97. **Bents and Towers:** Each trestle bent shall be composed preferably of two main supporting columns. Towers shall be composed of two (2) bents rigidly braced and strutted both longitudinally and transversely.

92.98. **Single Bents:** Single bents shall have hinged ends, or else shall be designed to resist bending.

92.99. **Batter:** Bents preferably shall have a sufficient spread at base to prevent uplift under the assumed lateral loadings. In general, the width of the bent at its base shall not be less than one-third (1/3) of its height.

92.100. **Depth of Girders:** The depths of plate girders in viaducts preferable shall be uniform.

92.101. **Girder Connections:** Girders of tower spans shall be fastened at each end to the tops of the columns or to the cross girders. Preferably there shall be a line of girders resting directly over the columns. One end of the girders between towers shall be riveted to the support, and there shall be an effective expansion bearing at the other end. No bracing or sway frame shall be common to abutting spans.

If girders are not supported directly on the columns, provision shall be made for the transmission of the longitudinal forces to the tower bracing.

92.102. **Bracing:** Towers shall be thoroughly braced, both transversely and longitudinally, with stiff members having riveted connections. Longitudinal and transverse struts shall be placed at caps and bases and at all intermediate panel points. All bracing connections shall be made by gusset plates. The sections of members of longitudinal bracing in each panel shall not be less than those of the members in corresponding panels of the transverse bracing.

Column splices generally shall be located close to and above the panel points of the bracing.

Horizontal diagonal bracing shall be provided at the tops and bases of towers and at least at all intermediate panel points of the lateral bracing where the tower columns are spliced.

Provision shall be made in column bearings for expansion of the tower bracing. The struts at the base of towers shall be strong enough to slide the movable shoes with the structure unloaded. The coefficient of friction shall be taken at twenty-five hundredths (0.25).

92.103. **Sole and Masonry Plates:** Sole and masonry plates shall each be not less than three-quarter (¾) inch thick.

92.104. **Anchorage:** Viaduct bents preferably shall have a sufficient spread at the base to prevent tension in any windward leg. When this is impracticable, the column anchorages shall be designed to safely resist not less than one and one-half (1½) times the calculated uplift.

92.105. **Approval of Plans:** The construction plans shall consist of shop detail, erection and other working plans showing details, dimensions, sizes of material and other information and data necessary for the complete fabrication and erection of the metal work. Approval of the construction plans shall be secured before fabrication of steel work is commenced.

The Contractor shall furnish the Engineer with such blueprint copies of the plans as may be required for approval and construction purposes and upon completion of the work the original plans if required shall be supplied to the Engineer. No deviation from the approved plans will be permitted without the written order of the Engineer.

SECTION 93

CONCRETE DESIGN

93.01. **General Assumptions:** The design of reinforced concrete members under these specifications shall be based on the following assumptions:

(a) Calculations are made with reference to unit working stresses and safe loads, as elsewhere specified herein, rather than with reference to ultimate strength and ultimate loads.

(b) A plane section before bending remains plane after bending.

(c) The modulus of elasticity of concrete in compression is constant within the limits of working stresses; the distribution of compressive stress in flexure is therefore rectilinear.

(d) The value of the modulus of elasticity of concrete shall be assumed as one-fifteenth (1/15) that of steel in computations of strength; and shall be assumed as one-eighth (1/8) that of steel in computing the deflection of reinforced concrete beams which are free to move longitudinally at the supports.

(e) Concrete shall be assumed as offering no tensile resistance.

(f) The bond between concrete and metal reinforcement is assumed to remain unbroken throughout the range of working stresses. Under compression the two materials are therefore stressed in proportion to their moduli of elasticity.

(g) Initial stress in the reinforcement due to contraction or expansion of the concrete is neglected, except in the design of reinforced concrete columns.

93.02. **STANDARD NOTATION**

Rectangular Beams:

f_s = tensile unit stress in longitudinal reinforcement.
f_c = compressive unit stress in extreme fiber of concrete.
E_s = modulus of elasticity of steel.
E_c = modulus of elasticity of concrete.

$n = \frac{E_s}{E_c}$

M = bending moment, or moment of resistance in general.
A_s = effective cross-sectional area of tension reinforcement.
b = width of beam.
d = effective depth, or depth from compression surface of beam to center of tension reinforcement.
k = ratio of depth of neutral axis to effective depth, d.
j = ratio of lever arm of resisting couple to depth, d.
jd = d–z = arm of resisting couple.

p = ratio of effective area of tension reinforcement to effective area of concrete in beam $= \frac{A_s}{bd}$

T-Beams:

b = width of flange.
b′ = width of stem.
t = thickness of flange.

Beams Reinforced for Compression:

A′: = area of compressive steel.
p′: = ratio of effective area of compression reinforcement to effective area of concrete in beam $= \frac{A'}{bd}$

f'_s = compressive unit stress in longitudinal reinforcement.
C = total compressive stress in concrete.
C' = total compressive stress in steel.
d' = depth from compression surface of beam to center of compression reinforcement.
z = depth from compression surface of beam to resultant of compressive stresses.

Shear, Bond and Web Reinforcement:

V = total shear.
V' = external shear on any section after deducting that carried by the concrete.
v = shearing unit stress.
u = bond stress per unit of area of surface of bar.
o = perimeter of bar.
Σo = sum of perimeters of bars in one set.
a = spacing of web reinforcement bars measured perpendicular to their direction.
s = spacing of web reinforcement bars, measured at the netural axis and in the direction of the longitudinal axis of the beam.
A_v = total area of web reinforcement in tension within a distance, a, or the total area of all bars bent up in any one plane.
α = angle between web bars and longitudinal bars.
f_v = tensil unit stress in web reinforcement.

Columns:

A = total net area.
A_c = net area of concrete in the column (total column area minus steel area).
A_s = effective cross-sectional area of longitudinal reinforcement.
P = total safe load.

93.03. DESIGN FORMULAS

Flexure of Rectangular Reinforced Concrete Beams and Slabs

Computations of flexure in rectangular reinforced concrete beams and slabs shall be based on the following formulas:

(a) **Reinforced for Tension Only:** (See Figure 7)

Position of neutral axis,

$$k = \sqrt{2pn + (pn)^2} - pn$$

Arm of resisting couple,

$$j = 1 - \frac{k}{3}$$

Compressive unit stress in extreme fiber of concrete,

$$f_c = \frac{2M}{jkbd^2} = \frac{2pf_s}{k}$$

Tensil unit stress in longitudinal reinforcement,

$$f_s = \frac{M}{A_s jd} = \frac{M}{pjbd^2}$$

Steel ratio for balanced reinforcement,

$$p = \frac{1}{2} \frac{1}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c} + 1\right)}$$

Note:—For approximate computations, the following assumptions may be made:

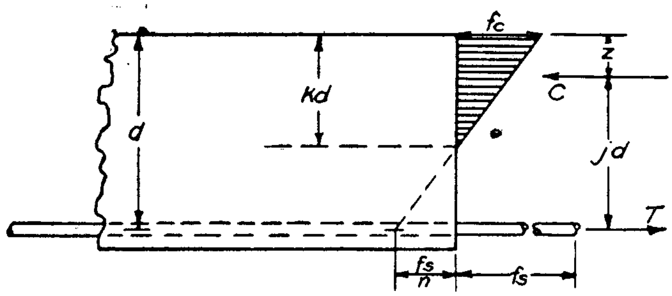


Fig. 7

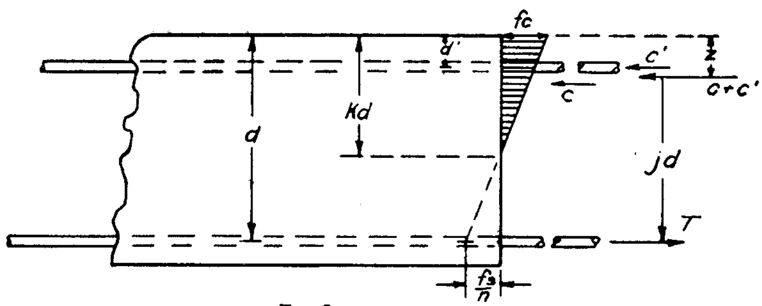


Fig. 8

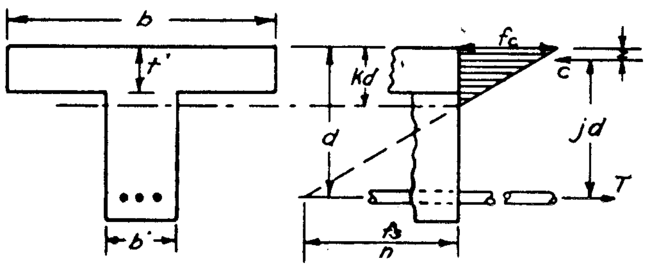


Fig. 9

$$j = 7/8$$
$$k = 3/8$$
$$A_s = \frac{M}{14000d}$$
$$f_c = \frac{6M}{bd^2}$$

(b) **Reinforced for both Tension and Compression:** (See Figure 8)

Position of neutral axis

$$k = \sqrt{2n\left(p + p'\frac{d'}{d}\right) + n^2 (p + p')^2} - n (p + p')$$

Position of resultant compression,

$$z = \frac{1/3k^3d + 2p'nd'\left(k - \frac{d'}{d}\right)}{k^2 + 2p'n\left(k - \frac{d'}{d}\right)}$$

Arm of resisting couple,

$$jd = d - z$$

Compressive unit stress in extreme fiver of concrete.

$$f_c = \frac{6M}{bd^2\left[3k - k^2 + \frac{6p'n}{k}\left(k - \frac{d'}{d}\right)\left(1 - \frac{d'}{d}\right)\right]}$$

Tensile Stress in longitudinal reinforcement,

$$f_s = \frac{M}{pjbd^2} = nf_c \left(\frac{1 - k}{k}\right)$$

Compressive stress in longitudinal reinforcement,

$$f'_s = nf_c \left(\frac{k - \frac{d'}{d}}{k}\right)$$

Flexure of Reinforced Concrete T-Beams: (See Figure 9):

Computations of flexure in reinforced concrete T-beams shall be based on the following formulas:

(a) **Neutral Axis in the Flange:**
Use the formulas for rectangular beams and slabs.

(b) **Neutral Axis Below the Flange:**
The following formulas neglect the compression in the stem.

Position of the netural axis,

$$kd = \frac{2ndA_s + bt^2}{2nA_s + 2bt}$$

Position of resultant compression,

$$z = \left(\frac{3kd - 2t)}{2kd - t}\right)\frac{t}{3}$$

Arm of resisting couple,

$$jd = d - z$$

Compressive unit stress in extreme fiber of concrete,

$$f_c = \frac{Mkd}{bt\,(kd - \frac{1}{2}t)\,jd} = \frac{f_s}{n}\left(\frac{k}{1-k}\right)$$

Tensile unit stress in longitudinal reinforcement,

$$f_s = \frac{M}{A_s jd}$$

(For approximate results, the formulas for rectangular beams may be used),

The following formulas take into account the compression in the stem; they are recommended where the flange is small compared with the stem:

Position of netural axis,

$$kd = \sqrt{\frac{2ndA_s + (b-b')\,t^2}{b'} + \left(\frac{nA_s + (b-b')\,t}{b'}\right)^2} - \frac{nA_s + (b-b')\,t}{b'}$$

Position of resultant compression,

$$z = \frac{(kdt^2 - 2/3t^3)\,b + [\,(kd-t)^2\,(t + 1/3\,(kd-t)\,]\,b'}{t\,(2kd-t)\,b + (kd-t)^2 b'}$$

Arm of resisting couple,

$$jd = d - z$$

Compressive unit stress in extreme fiber of concrete,

$$f_c = \frac{2Mkd}{[(2kd-t)\,bt + (kd-t)^2 b')]\;jd}$$

Tensile unit stress in longitudinal reinforcement,

$$f_s = \frac{M}{A_s jd}$$

Shear, Bond and Web Reinforcement:

Diagonal tension and shear in reinforced concrete beams shall be calculated by the following formulas:
Shearing unit stress,

$$v = \frac{V}{bjd}$$

Stress in vertical web reinforcement,

$$f_v = \frac{V's}{A_v jd}$$

When a series of web bars or bent-up longitudinal bars is used, the web reinforcement shall be designed in accordance with the formula:

$$A_v = \frac{V'a}{f_v jd} = \frac{V's \sin \alpha}{f_v jd}$$

When the web reinforcement consists of bars bent up in a single plane so as to reinforce all sections of the beam which require it, the bent up bars shall be designed in accordance with the formula:

$$A_v = \frac{A'}{f_v \sin \alpha}$$

The bond between concrete and reinforcement bars in reinforced concrete beams and slabs shall be computed by the formula:

$$u = \frac{V}{jd\Sigma o}$$

(For approximate results "j", in the above formulas, may be taken as 7/8.)

As regards shear and bond stress for tensil steel, the above formulas apply also to beams reinforced for compression.

Columns with Lateral Ties:

The safe axial load on columns reinforced with longitudinal bars and separate lateral ties or hoops shall be determined by the formula:

$$P = f_c\,(A_c + nA_s) = f_c A\,(1 + (n-1)\,p)$$

Compressive unit stress in concrete:

$$f_c = \frac{P}{A\,(1 + (n-1)\,p)}$$

Compressive unit stress in longitudinal reinforcement,

$$f_s = nf_c$$

93.04. **Effective Span Lengths:** The effective span lengths of freely supported beams and slabs shall be the distance between centers of the supports, but shall not exceed the clear span plus the depth of beam or slab. The span length for continuous or restrained beams built monolithically with supports shall be the clear distance between faces of supports. Where brackets having a width not less than the width of the beam, and making an angle of forty-five (45°) degrees or more with the axis of a restrained beam, are built monolithically with the beam and support, the span shall be measured from the section where the combined depth of the beam and bracket is at least one-half (½) more than the depth of the beam. Maximum negative moments are to be considered as existing at the ends of the span, as above defined. No portion of a bracket shall be considered as adding to the effective depth of the beam.

93.05. **Moments in Floor Sab:** Concrete floor slabs built continuously over supporting beams or joists shall be designed for eighty percent (80%) of the maximum live load bending moment of a simply supported slab of the same span.

93.06. **Expansion Joints:** Provision for end expansion shall be made in all concrete slabs or girder bridges having a clear span length in excess of forty feet (40′). When multiple span construction is used, of spans forty feet (40′) or less in length expansion joints shall be provided at intervals of not more than eighty (80) feet. When no expansion joints are used, the superstructure being cast intergrally with the abutments, the reinforcement in the slab or girders shall be increased to provide for the thermal forces induced by a temperature drop of forty (40) degrees Fahrenheit.

In concrete floors or metal structures, expansion joints shall be provided at both fixed and expansion ends of the span.

93.07. **T-BEAMS.**

Effective Flange Width: In beam and slab construction, effective and adequate bond and shear resistance shall be provided at the junction of the beam and slab. The slab may then be considered an integral part of the beam but its assumed effective width as a T-beam flange shall not exceed the following:

(a) One-fourth of the span length of the beam.
(b) The distance center to center of beam.
(c) Six times the width of the beam.
(d) Eight times the least thickness of the slab plus the width of the girder stem.

Shear: The flange of the slab shall not be considered as effective in computing the shear and diagonal tension resistance of T-beams.

Isolated Beams: Isolated beams in which the T-form is used only for the purpose of providing additional compression area, shall have a flange thickness of not less than one-half (½) the width of the web, and a total flange width of not more than four (4) times the web thickness.

Diaphragms: For T-beams spans over forty (40) feet in length diaphragms or spreaders shall be placed between the beams at the middle or third points.

93.08. **REINFORCEMENT**

Spacing: The clear distance between reinforcing bars preferably shall not be less than three (3) inches and, in slabs, not more than one and one-half (1½) times the thickness of the slabs.

The minimum covering, measured from the surface of the concrete to the face of any reinforcing bar, shall be not less than two (2) inches except in slabs where the minimum covering shall be one (1) inch. In the footings of abutments and retaining walls and in piers the minimum covering shall be three (3) inches. In work exposed to the action of sea water the minimum covering shall be four (4) inches except in precast concrete piles where a minimum of three (3) inches shall be used.

Splicing: Tensile reinforcement shall not be spliced at points of maximum stress. When reinforcement is spliced, the splice bars shall lap sufficiently to develop the full strength in bond.

Anchorage: Anchorage of longitudinal reinforcement may be provided by extending the bars a sufficient distance beyond the theoretical point of termination to develop their full strength in bond. Anchorage may also be provided by bending the end of the bar through one-hundred-eighty (180) degrees to a diameter not less than six (6) times the diameter of the bar, the total length of the hook being not less than sixteen (16) diameters of the bar.

Reinforcement for negative moment shall be thoroughly anchored at or across the support, or shall extend into the span a sufficient distance to develop by bond the tensile stresses.

Maximum Sizes: The maximum size of bar reinforcement shall be one and one-fourth (1¼) inches square or equivalent, unless the particular conditions warrant the adoption of special reinforcement design. When structural steel shapes are used for reinforcement, no section having a surfaced area per foot of length of more than one-hundred-fifty (150) square inches shall be used as a reinforcing member unless mechanical bond is provided by means of lugs, bars or other details which will effectively bond the member to the surrounding concrete mass.

93.09. **Design of Web Reinforcement:** When the allowable unit shearing stress for concrete is exceeded, web reinforcement shall be provided by one of the following methods:

(a) Longitudinal bars bent up in series or in a single plane.
(b) Vertical stirrups.
(c) Combination of bent-up bars and vertical stirrups.

When any of the above methods of reinforcement are used, the concrete may be assumed to carry external vertical shear not to exceed forty (40) pounds per square inch, the remainder of the shear being carried by the web reinforcement.

The webs of T-beams shall be reinforced with vertical stirrups in all cases.

Bent-Up Bars: Bent-up bars used as web reinforcement may be bent at any angle between twenty (20) and forty-five (45) degrees with the longitudinal reinforcement. The radius of bend shall not be less than four (4) diameters of the bar.

The spacing of bent-up bars shall be measured perpendicular to their direction and in a plane parallel to the longitudinal axis of the beam. This spacing shall not exceed three-fourths (¾) of the effective depth of beam. The first bar from the support shall cross the neutral axis of the beam at a distance from the face of the support, measured along the axis of the beam, not greater than one-fourth (¼) of the effective depth.

Vertical Stirrups: The spacing of vertical stirrups shall not exceed three-fourths (¾) of the effective depth of the beam. The first stirrup shall be placed at a distance from the face of the support not greater than one-fourth (¼) of the effective depth of the beam. Stirrups shall surround three sides of the tensile reinforcement.

Anchorage: Web reinforcement shall be securely anchored in the compression portion of the beam, which may be considered as developing bond for a vertical distance equal to four-tenths (4/10) the effective depth of the beam. Stirrups and bent-up bars shall be securely anchored to the tensile reinforcement.

93.10. **Columns:** The ratio of the unsupported length of a column to its least diameter or dimension shall not exceed four (4) for unreinforced and fifteen (15) for reinforced sections. The least diameter or dimension in no case shall be less than fifteen (15) inches. For reinforced concrete viaduct construction or for "pedestal" or "buried" abutments, the least dimension shall be not less than twenty-four (24) inches.

The reinforcement of columns shall consist of at least four (4) longitudinal bars tied together with lateral ties or hoops enclosing the longitudinal reinforcement. The longitudinal reinforcement shall be of bars not less than one (1) inch in diameter and shall have a total cross-sectional area of not less than seven-tenths (0.7%) per cent of the total cross-sectional area of the column. Reinforcement in excess of two (2%) per cent of the cross-sectional area of the column shall not be considered in computing compressive stresses. The lateral ties or hoops shall be not less than one-fourth (¼) inch in diameter and space not farther apart than twelve (12) inches.

Bending: When columns are subjected to bending stresses due to eccentric loads, monolithic construction or lateral forces, they shall be so proportioned that the combined direct and bending stresses shall not exceed the allowable unit compressive stresses herein specified.

Columns placed in earth fills, as in the case of "pedestal" or "buried" abutments, shall be designed to withstand the earth pressure from the rear, disregarding the effect of the fill in front.

Column Struts: Longitudinal or lateral struts used to brace columns shall be proportioned to support a uniform load equal to at least twice the dead load of the strut.

93.11. CONCRETE ARCHES

Shape of Arch Ring: Arch rings shall be selected as to shape in such a manner that the axis of the ring shall conform, as nearly as practicable to the equilibrium polygon for full dead load or, if desired, to the equilibrium polygon for full dead plus one-half (½) live load over the full span.

Spandrel Walls: When the spandrel walls of filled spandrel arches exceeds five (5) feet in height above the intrados they shall be designed as vertical slabs supported by transverse diaphragm walls or deep counterforts. Vertical cantilever walls over five (5) feet in height, or counterforts having a back slope of less than forty-five (45) degrees with the vertical, shall not be used, on account of the excessive and indeterminate stresses set up in the arch ring by torsion.

Expansion Joints: Vertical expansion joints shall be placed in the spandrel walls of arches to provide for the movement due to the temperature change and arch deflection. These joints shall be placed at the ends of spans and at intermediate points, generally not more than fifty (50) feet apart.

Reinforcement: Arch rings in reinforced concrete construction shall be reinforced with a complete double line of longitudinal reinforcement consisting of an intradosal system and an extradosal system connected by a series of stirrups or tie-rods.

For barrel arches, a system of transverse reinforcement, thoroughly anchored to the longitudinal reinforcement, shall be used in both intrados and extrados. The transverse reinforcement shall be proportioned to resist the bending stresses, due to any overturning action of the spandrel wall.

For rib arches, hoops or tie bars shall be used in connection with the longitudinal rib reinforcement, as in the case of reinforced concrete columns due to any overturning action of the spandrel wall.

Waterproofing: Preferably, the top of the arch ring and the interior faces of the spandrel walls of all filled spandrel arches shall be waterproofed with a membrane waterproofing constructed in accordance with the requirements specified in Section 84.

Drainage of Spandrel Fill: The fills of filled spandrel arches shall be effectively drained by a system of tile drains or French drains laid along the intersections of the spandrel walls and arch ring and discharging through suitable outlets in the piers and abutments. The location and detail of the drainage outlets shall be such as to eliminate, as far as possible, the discoloration by drainage water of the exposed masonry faces.

93.12. **Viaduct Bents and Towers:** When concrete columns are used in viaduct construction, bents and towers shall be effectively braced by means of longitudinal and transverse struts. For heights greater than forty (40) feet, both longitudinal and transverse cross or diagonal bracing preferably shall be used and the footings for the columns forming a single bent shall be thoroughly tied together.

SETION 94

DESIGN OF TIMBER STRUCTURES

94.01. Bolts: Bolts of diameters not exceeding one (1) inch preferably shall be spaced not closer than six (6) inches center to center, not less than six (6) inches from the center of the bolt to the end of any timber, and not less than two and one-half (2½) inches from the center of the bolt to the other side of any timber. These distances preferably shall be increased for bolts larger than one inch (1") in diameter. Inclined bolts through timber preferably shall be provided with beveled cast washers to eliminate the cutting of inclined daps in the timber.

94.02. Washers: A washer shall be used under all bolt heads and nuts which would otherwise come in contact with wood. Washers may be cast of plate and shall be designed to prevent excessive crushing of the wood when the bolts are tightened. For bolts in an important location, such as joints and splices, and for rods, the washers shall be designated to develop the bolt or rod in tention at the unit bearing stresses specified for compression perpendicular to the grain of timber.

A standard circular washer shall be used under the heads of all lag screws.

94.03. Hardware for Sea-Coast Structures: The hardware used in structures on the sea-coast preferably shall be galvanized.

94.04. Columns and Posts: No column shall have an unsupported length greater than thirty (30) times its least dimension.

The strength of built-up columns composed of two or more sticks bolted together, either with or without packing blocks, shall be considered as equal to the combined strength of the single sticks, each considered as an independent column.

94.05. Pile and Framed Bents:

Pile Bents: Pile bents generally shall not exceed forty (40) feet in height. Pile bents over ten (10) feet high shall be sway-braced transversely with diagonal braces on each side of the bent, and shall be adequately braced longitudinally. In general, pile bents shall contain not less than four bents each and the outside piles preferably shall be battered. The pile shall be designed for safe bearing and for column action.

Framed Bents: Framed bents may be supported on piles, concrete pedestals or mud sills. All bents shall be sway-braced transversely and adequate provision shall be made for longitudinal bracing. In general, framed bents shall contain not less than four (4) posts each and the outside post of the bent shall be battered. The posts shall be designed as columns.

Sills and Mud Sills: Mud sills, and all sills which are to be located in close proximity to the ground surface, preferably shall be given a preservative treatment. When possible, the design shall be such as to insure that sills will be located clear of all earth so that there may be a free circulation of air around them. Sills shall be fastened to mud sills or piles with drift bolts of not less than three-fourths (¾) inch diameter and extending into the mud sills or piles at least six (6) inches. Sills shall be fastened to pedestals with dowels of not less than three-fourths (¾) inch diameter, set in the pedestals and extending into the sills at least six (6) inches.

Posts shall be fastened to sills by dowels of not less than three-fourths (¾) inch diameter extending at least six (6) inches into posts and sills, or by drift bolts of not less than three-fourths (¾) inches diameter driven diagonally through the base of the posts and extending at least nine (9) inches into the sill. Posts shall be fastened to pedestals with dowels of not less than three-fourths (¾) inch diameter and extending into the posts at least six (6) inches.

Caps: Timber caps shall be not less in size than ten (10) by ten (10) inches. They shall be fastened with drift bolts of not less than three-fourths (¾) inch diameter, extending at least nine (9) inches into the piles or posts.

Bracing: Single story bracing shall not exceed twenty (20) feet in height. The minimum size of transverse sway braces shall be three (3) by eight (8) inches. All bracing shall be bolted through the piles, posts or caps at the ends; at intermediate intersections it may be bolted or spiked. In all cases, spikes shall be provided in addition to bolts. The bolts used shall be of not less than five-eights (5/8) inch diameter.

Pile Bent Abutments: Pile bent abutments shall be adequately braced or anchored to resist earth pressure. Bulkhead plank shall be not less than three (3) inches thick and preferably shall be treated. It shall be fastened to the piles with spikes, the length of which shall be at least three (3) inches greater than the thickness of the plank.

94.06. TRUSSES

Joints and Splices: Joints shall be detailed to shed water to the maximum degree practicable. Joints and splices shall be designed to develop the computed stresses in the members connected and preferably to develop the full strength of those members. Posts or struts bearing against the sides of timber members preferably shall be provided with metal end bearings. Joints involving end bearing or inclined surfaces shall be avoided, preference being given to square-cut ends of timbers bearing against blocks.

In end-shoe plates and tension-splice plates the bearing faces of lugs or tables shall have a smooth even surface. If rolled plates or bars are used for tables, they shall be milled or cold sawed on the bearing edges. The bolts holding the lugs or tables in the notches in the timber shall be placed as near to the lugs or tables as possible. No metal lug or table shall have a bearing face less than five-eights (5/8) inch thick. In details of end-shoes employing lugs of tables set in the lower chord, the spacing of such lugs or tables shall be arranged so that no lug or table occurs directly under the end of the end post. The end joint between lower chord and end post shall provide definite lines of action and shall be a simple joint depending for its strength upon type of detail. When inclined bolts are used to connect the main members of an end-joint, such bolts shall be at an angle of not more than sixty (60) degrees with the center line of lower chord. Holes in timbers for inclined bolts in details employing end-shoe plates shall be one-fourth (¼) inch larger than the nominal diameter of the bolt.

No daps in chords for butt blocks shall be less than three-fourths (¾) inch deep.

Tension splices shall be of such a type that the effects of cross shrinkage of the timber will be a minimum. Neither steel table fish plates nor shear pin splices shall be used on timbers over eight (8) inches thick, since the cross shrinkage of the timber will allow the plates or pads to separate. The shear-pin joint shall be used only with fully seasoned timber and gas-pipe shall not be used for shear pins.

Floorbeams: Floorbeams shall be sized at bearing points. In floorbeams composed of two or more timbers, the timbers shall be separated by at least two (2) inches for air circulation. Floorbeams shall be connected to the main truss members by means of rods or structural shapes.

Hangers: Hangers generally shall be rods having upset ends with a suitably designed washer or bearing plate at each end. Upset ends shall conform to the requirements specified for Structural Steel Design, Division 4, Paragraph 4.6.00.

Eyebars and Counters: The requirements specified for Structural Steel Design, Section 92 for counters, eyebars and eyebar packing shall apply to such members when used in timber trusses.

Bracing: Timber trusses shall be provided with a rigid system of laterals in the plane of the loaded chord. When the details will permit, this lateral bracing shall be securely fastened to all longitudinal stringers. Lateral bracing, preferably rigid, in the plane of the unloaded chord, and rigid portal and sway bracing shall be provided in all trusses having sufficient head room. Outrigger brackets connected to extensions of the floorbeams shall be used for bracing through trusses having head room insufficient for a top lateral system.

Camber: Camber, in addition to that required to provide for dead load and shrinkage, shall be provided in timber trusses in sufficient amount to give the structure a good appearance.

94.07. FLOORS AND RAILING

Stringers: Stringers shall be of sufficient length to take bearing over the full width of caps or floorbeams, except outside stringers which may have butt joints. Preferably they shall be of two panel lengths placed with staggered joints. The lapped ends of untreated stringers shall be separated at least one-half (½) inch for air circulation. Stringers shall be secured to caps or floorbeams.

Bridging: Stringers shall be braced by cross bridging in each panel. The bridging shall be not less in size than two (2) inches by four (4) inches.

Nailing Strips: When timber floors are supported by steel joists, the joists shall be provided with nailing strips which shall be bolted either to the top flanges or the webs.

When nailing strips are bolted to the flanges they shall be used on all joists. They shall be not less than four (4) inches deep and shall be wider than the supporting flange. They shall be secured with five-eights (5/8) inch bolts through the flanges, spaced not more than four (4) feet apart and not more than eighteen (18) inches from the ends of the strips.

Nailing strips bolted to the webs shall be not farther apart than five (5) feet and shall be not less than four (4) inches thick to provide a spiking face of sufficient width. They shall be held clear of the flanges by blocks between the web and strip, and bolted through the web with five-eights (5/8) inch bolts spaced not more than four (4) feet apart and not more than eighteen (18) inches from the ends of the strips.

Flooring: Roadway floor plank shall have a nominal thickness of not less than three (3) inches. Sidewalk floor plank shall have a nominal thickness of not less than two (2) inches.

The minimum size of material used for laminated or strip floors shall be two (2) inches by four (4) inches.

Retaining Pieces: Retaining pieces, where required, shall be not less than six (6) inches in width. In general they shall be secured in place by five-eights (5/8) inch bolts at three (3) foot intervals and spiked at one (1) foot intervals.

Wheel Guards: Wheel guards having a cross section of not less than four (4) inches by six (6) inches shall be provided on each side of the roadway. The guard timbers shall be in lengths of not less than twelve (12) feet. They shall be secured with five-eights (5/8) inch bolts at the ends and at intermediate points not more than four (4) feet apart.

In strip floors or cambered floors, not provided with retaining pieces, the wheel guards shall be placed directly on the flooring with scupper holes at suitable intervals. In other floors the wheel guards shall be supported by scupper blocks not less than four (4) inches thick and one (1) foot long, held in place by spikes and a bolt through the wheel guard and flooring, and spaced not more than five (5) feet apart.

Cambered Floors: In strip floors or floors crowned for drainage, the ends of the flooring shall be securely held down by the retaining pieces or wheel guards. In this case the bolts through the retaining pieces or wheel guards shall pass through the flooring and through the outside stringer or spiking piece.

Drainage: Adequate provision shall be made for the proper drainage of timber floors.

Railings: Wood railings shall consist of not less than two horizontal lines of rails. Rails shall have a cross section not less than two (2) inches by six (6) inches.

Rail posts shall have a cross section not less than four (4) inches by six (6) inches and shall be spaced not more than eight (8) feet apart.

Preferably, rails shall be surfaced four sides (S4S) and painted white.

94.08. **Fire Stops:** To check the spread of fire lengthwise of the structure, timber floors or trestles of any considerably length preferably shall be provided with fire stops.

In timber floors these fire stops should be provided at intervals not over seventy-five (75) feet apart. They may consist of diaphragms of wood or fire resistant material at least as thick as the flooring, located over caps or floor beams and completely filling the openings between the joists.

In timber trestle bridges, in addition to the fire stops in the floor, fire curtains should be provided at intervals of one hundred (100) feet or more. These curtains may consist of plank or asbestos-covered metal spiked to the bents. They should extend downward from the bottom of the joists at least five (5) feet and horizontally at least to the ends of the caps. A fire stop between the joists should be located over each curtain.